HETEROPHORIAS AND INSUFFICIENCIES

SEABROOK

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A CLINICAL STUDY

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CHAPTER I.

GENERAL CONSIDERATIONS AND METHODS OF TESTING.

THE class of cases to be considered here has been recognized as having had an existence since the dawn of modern ophthalmology. Von Graefe attempted to solve the problems they presented, and although he furnished some valuable ideas for his successors to work upon, his knowledge upon the subject would be a poor equipment for an ophthalmologist of to-day. Donders saw the fallacies of the work being done in this field, solved in general terms the problem of accommodative asthenopia,

and found that "as soon as insufficiency of the internal or external recti muscles in binocular vision threatens to give rise to muscular asthenopia, it is of importance that the mutual distance of the glasses should not aggravate this but rather counteract it." If spherical glasses are insufficient, we are to combine with prisms or operate according to Von Graefe. There is agreement with Helmholtz's statement that displacement of glasses in a vertical direction causes more asthenopia than the same amount of lateral displacement. Except for the operative method indicated, the statements here made are entirely sound, but cannot be said to suffer from over-elaboration; they seem, however, sufficient to more than cover what is usually done for muscular asthenopia to-day in practice upon the European continent. In England signs of interest began to be manifested regarding these cases over fifteen years ago, and thanks to the work of Maddox and others many principles of value were evolved. Previous to this, Stevens in America had succeeded in attracting attention by means of his work, his highly enthusiastic followers, and his bitter opponents. A portion of his nomenclature came into general use, and is here followed. *Orthophoria*, muscular balance; *heterophoria*, tendency to deviation; *esophoria*, convergence tendency; *exophoria*, divergence tendency; *hyperphoria*, upward tendency. These terms were

taken to be equivalent to and supersede the old ones of insufficiency of the interni and externi, even Duane, whose masterly classification of these conditions has earned deserved recognition, taking this view; yet heterophoria means merely a tendency of the fixation lines away from the object of fixation, while insufficiency means lack of power. The old terms for exophoria and esophoria were dynamical divergence and convergence. It is the intention of the writer to show that certain forms of heterophoria may be due to errors of refraction or other optical defects, others to habit, others to the nervous system, and others still to muscular spasm, excess, or insufficiency. Much has been written upon this subject in addition to that so briefly mentioned, some of it of value, and the writer proposes to treat all of the authors in the most impartial manner, as he appropriates their ideas whenever he can make use of them, without regard to their source. He has no instruments to exploit, no special method of treatment to push, no new general disease which he has cured through the eye muscles. If, in spite of this, an original idea or so should creep in among the others, anybody is welcome to use it as his own.

In discussing the question of correcting the refraction except as incidental to the treatment of muscular anomalies, there is of course no intention to belittle this very important consideration in the

treatment of eye strain. Important as this branch of the subject undoubtedly is, correction of the refraction may be carried to the point of absurdity. When a patient with undoubted exophoria and insufficiency of the interni complains of severe headache, dizziness and nausea, excited or increased when convergence is attempted, it is perfectly silly to correct .12 or .25 D. of hypermetropia in such eyes, and yet many have done such things.

In studying the effect of correction of the refraction upon the ocular muscles, it is absolutely necessary to separate this secondary effect of glasses from the prismatic effect of a decentred lens. In order that the optical centre of a lens may be found, the lens should be held in front of a horizontal line in such a position that the line is continuous through the glass without deviation at either edge. The position of this line is then marked upon the glass and the process repeated at right angles to the first position; the lines cross at the optical centre and show in a sphero-cylindrical lens the axis of the cylinder and the maximum curve at right angles to it. In a simple cylinder the axis only can be found, as there is no prismatic displacement of a line at right angles to the axis; a cylinder with horizontal axis cannot be decentred horizontally, and similarly with the axis in other meridians. Two lines crossing at right angles may be used to find the optical centre

instead of the above-described method, or the lens may be held in front of an object, as a candle flame, in such a position that the reflected images from the surfaces of the glass are superimposed, when the position of the images shows the optical centre. The last method may be used for rapid verification under certain circumstances, but I prefer the first for several reasons. The base and apex of a prism are marked by a line continuous through the glass, just as the axis of a cylinder is. When the cylinder is revolved upon its centre, we notice a peculiarity of prismatic action due to the varying curves, which results in torsion of lines oblique to the axis, being most marked at an inclination of 45°. While there are causes for the distortion of objects caused by glasses other than simple prismatic effect, yet this prismatic action of the transparent cylinder has not only an important bearing upon the asthenopia produced by cylindrical lenses, but, taken in connection with other prismatic effects of curved surfaces and applied to the human eye with its frequently decentred astigmatic refractive media, it throws an entirely new light upon many observations in physiological optics and opens up a new field in the explanation of muscular anomalies. A very plausible connection could be shown between apparent divergence and convergence, the decentred biconvex lens system between the anterior corneal surface and

the posterior surface of the crystalline lens, and convergent and divergent squint; its bearing upon the subject in hand will be shown later.

The primary position of a pair of glasses in front of the eyes when it is desired to study their effects upon the ocular muscles is with the optical centres in the lines of fixation. This position can be obtained with considerable accuracy by sighting; that is, by making each examined eye fix the examiner's, when the optical centre of the glass is placed in the line which seems to correspond to the line of fixation of the former and the line of vision of the latter. If there is a question as to the correctness of this, discs with vertical stenopæic slits may be placed in an adjustable frame, and the distance between their centres measured when both eyes can see through the slits at the same time. This distance between the optical centres (o. c.) should not be confounded with the distance between the geometrical centres of glasses to be worn (p. d.), which should come opposite the pupils for the sake of appearance and because there will be less annoyance to the patient from the refraction and reflection at the edges of the lenses when they are symmetrical with the pupil.

The prismatic effect of a decentred spherical lens is obtained by multiplying the distance between the optical and geometrical centres, taken in centimetres and tenths, by the dioptric strength of the lens.

Thus, a 2 D. lens decentred 3 *mm.* equals a .6 D. prism, 2. × .3 = .6. In a pair of glasses the difference between the primary and secondary position is taken. Thus, if the glasses are 60 *mm.* o. c., and the lines of fixation cut them 57 *mm.* apart, the prismatic action of a pair of 2 D. lenses is .6 D., one half in each eye. If the number of centimetres of decentring to produce a certain prism is desired, the formula is $\frac{\text{P. D.}}{\text{D.}} = cms.$, in tenths. The base of the prism is, of course, toward the periphery of a concave lens, toward the centre of a convex one. If the curve of the lens and the position of the line of fixation are kept in mind, or put on paper, there can be no confusion. In a cylindrical lens the number of dioptries can be found in any direction by means of the lens measure and prismatic action then figured as for a sphere.

This easy method of figuring the prismatic action of a decentred lens is one of the merits of the prism dioptry system proposed by Mr. Charles Prentice, a layman, and adopted by many manufacturing opticians throughout the country on account of its simplicity and accuracy when applied to the manufacture of prisms. I began to use it soon after it was first suggested. The unit is the prismatic power which causes 1 *cm.* of light deviation at 1 *metre*. A lens of 1 D. refractive power decentred 1 *cm.* = 1 P. D. (△ D. or D.), 1. × 1. = 1. The best scale I know for

measuring prisms in this system is that of Dr. Ziegler. I propose to speak of heterophorias in terms of prism dioptries, just as we speak of hypermetropia and myopia in terms of the correcting glass. It is not necessary in either case to add dioptries or D. to the figures in decimals which designate the strength of the glasses, and it will generally be omitted in the following pages.

There are a few things regarding the action of prisms necessary to remember in clinical work. Prisms beyond a certain strength can not be used in correcting anomalies of the ocular muscles for several reasons, some relating to the effect upon the muscular action, others to mental effect upon the patient, and yet others to distortion due to prismatic astigmatism from the varying ratio between the angles of incidence and refraction. There is a position of minimum deviation in which a ray of light passes symmetrically through a prism and other rays suffer greater deflection. In testing for an object in the direction of the line of fixation, prisms should be placed with the surface toward the eye perpendicular to that line, in order to secure as nearly as possible the position of minimum deviation. The position of the prism may assume some importance in the case of a vertical prism, as, if this is placed in the position of minimum deviation for distance, its action is stronger for near points, the increase amounting to

about one-tenth of its strength for the nearest point at which the eyes are likely to be used.

As will be shown later, patients with inefficient ocular muscles do not bear prisms as well as those with strong muscular action; stronger prisms may be worn base in for near work than base out for distance, and with axis horizontal than vertical, and a 3 D. prism over each eye is about the limit of strength under favorable conditions.

Secondary images due to reflection from the surfaces of the glass cause more annoyance in glasses containing prisms than in those without them, but the colors due to dispersion, diminution in size and change of shape of an object, occur to a considerable extent only when a strong prism is placed before one eye, as in testing muscular power, or at least are remarked upon by patients mostly under this condition.

The eye moves toward the apex of a prism in order to overcome the deviation of rays of light toward the base, and when it is unable to do this diplopia results, with the image from the eye before which the prism is placed in the direction of the apex. The action of the interni in overcoming prisms base out is called adduction, the externi with prisms base in, abduction. These terms are easily confounded, and the mind becomes so confused and fatigued by them that I propose to use instead the

terms convergence and divergence. This can cause no confusion as the amount is always given in terms of measurement. P. D's of convergence and divergence cannot possibly be confounded with metre-angles or degrees, and those who use the term degrees, except as applied to perimetric measurements, cannot be cast into any more confusion by the innovation than that under which they now are laboring.

There is one point upon which there is agreement among all investigators in this direction: it is that abduction or divergence for distance with well balanced and strong eye muscles should be 7. or 8. [These figures are the same whether the old degree system, dioptry, or centrad is used. It is beside the purpose of this treatise to argue regarding these systems and the new system in degrees of Landolt. Whatever its demerits, the dioptric system has been (unofficially) adopted.] The student who finds that his investigations seem to contradict this standard for divergence should doubt the accuracy of his observations; with an abducting prism the double images may easily pass unnoticed when they first appear and then suddenly be observed a considerable distance apart at the time a stronger prism than represents divergence is being used. In such a case prisms of gradually decreasing strength should be used until single vision results, then gradually

increased again. After some experience the examiner will begin with the prism which is to his mind most likely to represent the divergence to be expected from the examinations previously made of the refraction and muscular balance. Until this experience is acquired it is well to start with a prism of 6., 7., 8., or 9. It has already been said that divergence which varies from 7. or 8. may be considered abnormal. A certain number of cases show but 6., in which the only criticism is that divergence and convergence are neither of them at their best. In other words, amplitude of convergence is slightly below the standard, and there is no other defect. An occasional case may be found in which the amplitude of convergence is so great that divergence of 9. or even 10. is equalized by correspondingly strong convergence and muscular balance is good. Such cases are liable to develop exophoria later, but for the time being are sometimes to be complimented upon their strong ocular muscles. Cases like this are perhaps not so infrequent as would appear from our histories. Persons with ocular muscles of that sort would not be apt to be weak or neurasthenic, and would hardly be bothered by trivial errors of refraction.

When it is said that divergence for distant vision should be 7. or 8., what is really meant is that this is what should be shown by the candle test at a

distance of about twenty feet, which is the usual test. It is in reality about 1. more than the actual power of divergence for infinity, as 1 D. of convergence is necessary for binocular fixation at twenty feet. It is fortunate that there should be such a definite standard of divergence for distance, since the power of divergence for distant vision is an important matter; divergence power for any near point theoretically would equal the amount required to bring the lines of fixation parallel, added to that which is still possible with parallel fixation lines when the eyes are adjusted for infinity. This total is obscured in making a test at a near point by the accommodative convergence and certain other factors, but while neither so definite nor important as divergence obtained for distance, it is a help in comparing the variations of the muscular action for near and far. At about thirteen inches (taken as the average reading distance) the prism test shows generally some 6 to 8 D's more of divergence than is shown by the test at twenty feet, the difference being less than this in cases of esophoria without insufficiency of convergence, greater in some cases of exophoria. Where divergence at thirteen inches is 18. or more, insufficiency of convergence power at that distance is almost sure to be present.

Convergence power for near work is of far more importance than it is for distance, which is also

fortunate, as the prism test for convergence at a distance is very variable. This variability is due mostly to the much greater difficulty some persons have of disassociating convergence and accommodation than others. If the only precaution taken in making the test is that of dividing the prisms between the examined eyes (a prism over one eye not only causes dissimilar images but often convergence in the armed eye alone, the other fixing), the proportion between convergence and divergence in eyes with orthophoria is apt to be as low as three to one. Convergence 18., divergence 6. is about the limit for useful ocular muscles on the one hand, while 70. versus 10. or even more can in rare instances be found among the strong muscles.

Convergence does not represent the strength of the interni alone, but the nervous energy put into them as well. In testing this power, being of too impatient a nature to wait for prism exercises or other slow methods, I have my patients fix a finger, or a lead pencil, which is gradually approached while the eyes are armed with converging prisms, and often with the exclamation, "Oh, that is what you want me to do," they proceed to converge at distance at least half as much again as they had succeeded in doing but a moment before. The rapidity and simplicity of this will absolutely prevent its acceptance as a cure, so I shall not elevate it to the dignity of a

method by giving it a name, as the principle itself is already in use under many high-sounding titles.

A moment's reflection will show anyone that the prism test at distance does not necessarily represent the real convergence power as shown by the near point for convergence. For the latter test I use a lead pencil or a penholder, as being an object which is always at hand during an examination, necessitates accommodation on the part of the patient in order that it shall be clearly seen, and allows the examiner to watch the action of the eyes without distracting his attention. The ease with which convergence for the near point is accomplished, and the steadiness with which the eyes hold an object, are of more importance than the exact measure of its distance from the eyes, and the sensations produced by this muscular action, with the attitude of the patient regarding them, are valuable diagnostic indications. I would, moreover, as soon trust my observation as to when convergence is no longer possible as a patient's statement regarding the production of diplopia. Tests for the near point usually will show more power of convergence than the prism test at distance, because in the latter instance the convergence without accommodation is an unwonted, as it is usually an unnecessary, accomplishment. Teaching a patient how to converge with prisms is simply training for a test, and has something of the same relation

to a cure of weak convergence as training a sensitive throat for the tongue depressor has to the treatment of hypertrophied tonsils.

The near point of convergence varies with the refraction and becomes more and more distant as age advances and accommodation and the interni become weaker. Undoubtedly valuable as the test for the near point of convergence may be, I confine my use of it mostly to certain purposes already mentioned, and as a check upon other tests. Thus if convergence with prisms for a distance seems below normal, I should reject a diagnosis of insufficiency of the interni, or of excess of the externi, if the same eyes showed easy and comfortable convergence up to two inches or less from the root of the nose, with or without the correction of the refraction. The prism test for convergence at the reading distance is unsatisfactory, although some information may be gained thereby, as in cases in which hyperphoria occurs only with convergence.

Sursumduction, or upward movement of an eye, is tested on the same principle as convergence and divergence: right sursumduction with the prism base down right eye, or base up left eye; left sursumduction base down left eye, base up right eye. It is hardly necessary to call attention to the necessity of verifying the base apex line of the prism and having this

axis exactly horizontal or vertical in the above mentioned tests.

Although it has been convenient to consider here the muscular strength as shown in divergence and convergence before the muscular balance or tendency to deviation, the latter should be tested before the former and preferably after examination of the refraction. The test for balance which is most time-honored is that by which vertical prisms produce diplopia, when if the images have a homonymous or crossed position as regards each other the correcting prism which brings them into equilibrium is considered the measure of the esophoria or exophoria. This test should be made at a distant and near point, first without, then with, the refraction corrected. I give the conclusions for a near point based upon tests at 13 inches, as this is the distance I have chosen for years, although now satisfied that it is somewhat too near for most cases. The near test would be best taken at reading distance, which varies in different individuals.

The test for equilibrium with prisms has been perfected, especially by Stevens, and has resulted in the phorometer with its two prisms of 5 D's base in, which can be rotated, after the test for vertical equilibrium has been obtained, for the test of the lateral tendency, and shows the amount and nature of the deviation upon its anterior surface

in prism dioptries when the images show equilibrium. It thus gives the novice information of the deviation with which he has to deal with some certainty, as he can hardly turn the instrument upside down or otherwise misplace it in making a test. When the axis of the prism is horizontal, if single vision still obtains it is a fair conclusion that divergence is excessive, and another prism may be added in order to obtain the lateral images, the prisms in the phorometer only being rotated in obtaining the measurements. An arm upon the instrument is very handy for getting the muscular balance at a near point, although the test object is more horizontal to the eyes than the position of the other objects most often seen at this distance in ordinary work. As a rule, deviations remain latent with this test to an extent that they do not with the rod test, although occasionally the reverse is true.

The Maddox glass rod, or series of rods, will produce a line of light at right angles to the axis when placed before an eye. This test has the advantage of indicating the fixing eye (the unarmed one) and allows it to be changed at will by changing the rod from one eye to the other. When the correcting prism is obtained its amount and direction are patent, thus saving the beginner in ophthalmology some mental effort in ordering correcting prisms. When a deviation has been corrected with a prism in one direction

the rod test will show the effect upon the deviation at right angles to it, a very important consideration in certain instances, as when with a correcting prism for hyperphoria we wish to test exophoria or esophoria as compared to the same deviation before the correction. The rod test also allows of an examination toward the periphery of the field more accurate than that of the phorometer, when we wish to see if the deviations are comitant, but is of no definite use in testing for reading distance. I can hardly see how either of these tests can be dispensed with.

The old screen test, in which one eye is covered, then uncovered, and its deviation noted while the other fixes, was in my hands so contradictory and unreliable long ago, that when Duane modified its use by adding a subjective element, giving the parallax test, I lacked sufficient confidence in the latter to use it, in which I may be wrong. Maddox rejected the double prism with bases meeting at the centre for the rod test, and various attempts have been made to revive its use for certain purposes, with but little success.

Having attempted to indicate the methods of examination which were followed in obtaining the clinical data here used, I shall treat the subject of heterophorias under the following heads: *Hyperphoria; Esophoria*, first, the accommodative, second,

esophoria from habit, lastly, esophoria from insufficiency of the externi or excess of the interni; *Exophoria*, accommodative and muscular; and lastly *Insufficiency of Convergence, Inefficiency of the Ocular Muscles, or Neurasthenic Muscular Asthenopia.* It may be observed that this class of cases is not intended to comprise, except as occasional reference may occur, those which have spontaneous diplopia, since I regard these as either cases of periodic squint, paresis of an ocular muscle, or of an associated movement; neither are other cases of evident strabismus without diplopia to be considered in detail. Although in practice it is difficult to draw the dividing line, it is primarily my desire to further definite knowledge regarding a class of cases in which individual muscles may of course be affected, yet the deviation can only be demonstrated by the heterophoria shown with appropriate tests.

It is lack of definite knowledge concerning deviations of both eyes above or below the horizontal plane, or inclinations of the physiological vertical meridian, which prevents consideration of these subjects here; at present, although the germs of ideas may be working in the brains of investigators upon these subjects, we can hardly accept information as definite where the diagnosis depends upon unproven points in physiology and optics and treatment consists of muscular exercises with oblique prisms, or

tenotomy of the upper half of one lateral muscle and lower half of its opponent. Torsion will receive some incidental consideration in dealing with muscular deviations connected with oblique astigmatism.

Before proceeding to the symptoms of the special deviations to be considered, it seems well to draw attention to certain signs of ocular asthenopia common to the different errors. They are mainly headache, dizziness and sensations of nausea, pain in the eyes, retinal asthenia or hyperesthesia, congestion of the palpebral or ocular conjunctiva. Any of these may be due to muscular anomalies; pain in the eyeballs seems often to occur from nutritive disturbances, as may conjunctival congestion, although the latter is generally connected with chronic nasal catarrh. Relief of conjunctival congestion by glasses may be due to protection of the eyes from dust and chemical rays of light, has occurred with plane glasses, or ridiculously weak spherical lenses, and is no proof of relief of eye strain. Asthenopic symptoms sometimes disappear when conjunctivitis is successfully treated. Temporal headache is usually due to astigmatism, the pain being most severe on the side of the functionally better eye, this being in men the right when refraction and vision are practically equal, because their habit of "sighting" objects with this eye renders them more "right eyed" than women. Next to eye

errors, tobacco and whiskey in men, uterine trouble in women, are the most important factors in temporal headache. Frontal headache, when dull, may be due to errors of refraction, but if severe and persistent suggests insufficiency of the interni, or disease of the frontal sinus. Supra-orbital neuralgia with tenderness over the nerve is usually unilateral and is best treated with quinine unless the pain is severe, radiating and persistent, with much lacrimation, when it should be referred to nasal obstruction, ethmoidal disease, or disease of some other of the accessory sinuses. In this latter condition there may be ciliary pain and lowered intra-ocular tension. A feeling of pressure over the top of the head about the fronto-parietal suture is from anæmia, not eye strain, and localized pain over one parietal protuberance is not an eye symptom, although its presence with accompanying tenderness is not a positive diagnostic sign of tumor of the brain, as is sometimes stated. Very severe headache with vomiting, coming on suddenly in persons who have not been subject to headaches, should always be regarded with suspicion, and if persistent, it will perhaps be necessary for a diagnosis between beginning cerebral disease and some lesion of the digestive organs to wait for further developments.

In " bilious attacks " there is sometimes paresis of an ocular muscle or of an associated movement

at the time of an attack which recurs with such attacks for years, and just such conditions of the muscles may occur and prove very misleading to the oculist in cases of central disease of the nervous system. Take, for instance, a case of recurrent pachymeningitis in an early stage, with headache and spasm of convergence from irritation of the convergence centre, or some other muscular trouble from central lesion which resembles some muscular excess or insufficiency in which treatment usually causes relief, and in such a case relief to the headache follows treatment of the eye muscles. It is hard to avoid mistakes in such cases, yet in them mistakes are very awkward; it weakens a man's local influence as an authority on muscular asthenopia when some of his medical neighbors have attended autopsies upon the late subjects of some of his late cures, and have not exercised that charity regarding faulty diagnosis which seems so often to begin at home.

Pain in the back of the neck, with dizziness and nausea, should immediately excite suspicion of heterophoria, or insufficiency of the ocular muscles. Tenderness over the upper portion of the spine, or the adjacent sensory nerves, does not argue against this. Similar pain with or without general headache has been known to occur in disease of the sphenoidal and ethmoidal sinuses, is present in brain

disease and lesions of the upper portion of the spine, and is given as a common symptom in nephritis, gout, stomach, intestinal and liver diseases, and especially in neurasthenia. In neurasthenia these symptoms I am satisfied should usually be referred to the eyes, and in particular to the ocular muscles. In cases in which these symptoms are especially dwelt upon as diagnostic of the general nervous condition they are frequently helped by treatment of eye strain, and I have myself sometimes in this manner received credit for curing neurasthenia through the eyes, although so far as I know I have never seen a case in which I could positively and justly claim any such cure. The same holds good in other conditions; the so-called gouty headache, and that of nephritis, may not uncommonly be relieved through eye treatment, because it was a symptom of an eye condition, not of gout, or kidney trouble; yet it would be absurd to claim that the general disease had yielded to cylinders, prisms, or operations upon the eye muscles. In patients with digestive disturbances, dizziness and nausea are more apt to occur from muscular asthenopia than in other cases, and these sensations no doubt occur frequently from other causes; yet so many of these cases are more or less benefited by eye treatment that, as before mentioned, the symptoms should excite suspicion of eye strain. Cases are seen by the eye

specialist in which eye treatment has been unduly delayed while general treatment was kept up for eye symptoms; he has no good opportunity to know the other side of the question.

The general rule of double causation must be applied in these cases; there are cases of eye deviations of the same character as those which cause trouble, which with just as hard use of the eyes cause no asthenopic symptoms whatever; hence these symptoms must be referred, when they occur from eye errors, to such errors working upon some general condition susceptible to these symptoms.

In the cases of choreic blepharospasm, or spasm of the facial muscles, occurring with or without other choreic symptoms, we are often able to obtain relief by treatment of heterophoria, refractive error, or inflammatory lesion of the eye or appendages, yet in an active stage of general chorea it has seemed to me that treatment of the ocular muscles sometimes did more harm than good; prisms cannot be kept straight in front of the eyes, the conditions of the muscles are so variable that it is hard to tell the nature of the original tendency, and muscle operations are likely to increase general nervous irritability.

Dizziness may go on to vertigo in certain cases of eye strain. Dizziness and giddiness are used properly as synonymous terms, while by vertigo is meant

temporary loss of consciousness. Vertigo in this sense is not of frequent occurrence from heterophoria, yet in occasional instances may take the form of fainting spells accompanied by falling. This is the only kind of epilepsy I have personally known to be relieved by eye treatment.

When a patient who is in the habit of reading himself to sleep gets eye strain and cannot sleep because he cannot read with comfort, correction of his eyes may cure his insomnia; yet eye treatment as a cure for insomnia has usually failed in my hands.

I have seen cases of nervous unrest accompanying hyperphoria or esophoria in which the patient said she felt like throwing herself out of the window, and met with one case in which there was ground to believe that the muscular deviation had actually helped to cause a temporary suicidal mania.

Statements on record to the effect that severe general headache, spinal irritation, dizziness and nausea are common symptoms of refractive error, because they disappear with correction of the refraction, are to be received with caution; a careful consideration of this matter convinces me that these symptoms are in such cases usually due to heterophoria which is incidentally relieved by correction of the refraction, as in accommodative esophoria.

Although the muscular deviations accompanying errors of refraction will receive our first

consideration, the symptoms will not be described from this class so much as from those cases in which the refractive error played no part, even if it existed.

It is well to remember that a headache which wakes a patient from sleep is not likely to be due to the eyes, and if it markedly decreases or disappears after the patient has been up and about for a time the eyes may be eliminated as a causative factor, except in a few cases where there is an eye error for near work which does not cause strain for distant vision; these latter cases are free from headache when they do no near work, but after hard use of the eyes in the evening may wake with a headache the next morning, which passes off later in the day.

It seems to be accepted as a matter of course that the asthenopia due to muscular deviations will cease if one eye only is used. The closing of one eye long enough for diagnostic purposes in the usual class of patients who suffer from asthenopia, with their weak nerves and strong desire for binocular fixation, is fraught with difficulty, and this principle finds its application mostly in the treatment of anisometropia. There may be an occasional case in which it is advisable to shut off one eye with a piece of ground glass in a spectacle frame for the diagnosis or relief of asthenopia, and personally I prefer this method to the removal of an eye which must necessarily be possessed of useful vision, a feat which I

am forced to believe by reliable authority has been performed for the relief of symptoms supposed to be due to heterophoria.

Of course the symptoms of muscular asthenopia depend upon binocular vision, and the man who expects to cure strain in one eye by tiring them both would hardly be expected to meet with success; yet I frequently find a patient with a plane or nearly plane glass over one eye and a strong lens over the other, who announces that the oculist who gave these glasses found that one eye was doing all the work, and corrected the other with a glass so that it might relieve the strain from which the first one was suffering. Many men have gone through the phase of full correction of each eye, as their seniors did not properly warn them, not caring to dwell upon that time when they too had discovered the secret of the cure of all asthenopia with good vision in either eye. A patient with anisometropia with much difference between the refraction of the eyes will bear full correction of the two eyes just so long as he does not use them together. There are many other difficulties of fusion in such a case in addition to the esophoria in one lateral direction, the exophoria in the opposite one, the hyperphoria on one side upon looking down, on the other when looking up, from the prismatic action of one lens in excess of the other; even if the patient looks through the centre

of the lens, or the English proposition is carried out to have the strength of the lenses similar at the periphery with a central paster to correct the eye with greater error, the unequal antero-posterior shifting of the nodal points, with other reasons for dissimilar retinal images, will still obtain.

To my mind the most satisfactory combination of eyes for a life's work would be to have one emmetropic, the other myopic about 3 D's. In cases of anisometropia in which the difference corresponds to this, yet astigmatism is present, it is well to consider the astigmatism alone; in myopia with a difference of 2. or 3. between the eyes it is well to have a pair of glasses in which the eye with less myopia is fully corrected by a glass and the other lens matches this or nearly so. I carry this idea so far as to occasionally correct in hypermetropic and presbyopic cases the eye with the greater error for distance, and with a glass which equals this in strength, as nearly as the case will allow, the presbyopia of the other as well. It is absolutely necessary to determine that the first eye does not strain its accommodation in order to read with the other, and render such correction impracticable.

The scope of this treatise will not allow a full discussion of this class of cases, in which any man is liable to meet with disaster, further than to give a few additional points regarding correction. The

deviation of the eye with poorer vision (fortunately the one with greater error in most instances) is determined by certain conditions in the better eye as well as its own weaknesses. Note in this connection the effect upon the defective eye of correcting glasses upon the better eye in squint cases. It is a matter of great importance to find out in such cases just how strong is the impulse to binocular fixation and the ability to ignore or suppress the image of one eye; if the muscular condition is bad and the tendency to binocular fixation can be strengthened, it is justifiable to cultivate the latter in the interests of vision, although muscular asthenopia may result which demands treatment.

The difference in strength between two glasses to which the eyes may accustom themselves depends upon the age and character of the patient and the condition of the ocular muscles, with some other factors which cannot be determined clinically at present. With one exception, cylinders with considerable amount of difference are borne better than spheres with like differences because there is no prismatic effect in the direction of the axis; differences between cylinders with the axes vertical are better borne than in those with the axes horizontal. Patients with strong muscular action, especially in the direction of difference (for instance, strong sursumduction with horizontal cylinders) bear differences better than

those with weak muscular action; this is partly local, partly because the latter condition accompanies neurasthenia. Sursumduction of 1. is weak, 2. ordinary, 2.50 and above strong. People who turn the head and look through the centres of their glasses bear glasses better than those who look at objects through or beyond the edges. Difference of glasses of 2. may be well borne by young people (under twenty years of age), while 1. may be the limit past middle life. The best borne differences are in cylinders with vertical axes as before mentioned, and the worst are a vertical cylinder over one eye, horizontal over the other, in this case concave cylinders being worse borne than the convex; in myopic astigmatism cylinder .5 in each eye, one vertical, the other horizontal, is usually not a complete success.

Let me repeat for the benefit of those who have had no trouble so far in giving glasses with great differences, that almost invariably the patient in such cases suppresses the image of one eye, or at least does not have binocular vision. The only cases in which such a correction is really indicated occur among patients with no tendency to asthenopia where it is desirable to better the field on the side of the defective eye.

CHAPTER II.

HYPERPHORIA.

THE symptoms of hyperphoria differ from those of other forms of heterophoria mostly in degree. The headache is below the occiput, or may be general and accompanied by dizziness and nausea; it is pretty constant, although varying in intensity, in many cases perhaps passing away during a night's rest and increasing toward evening, unless the patient rests with the eyes shut during the day; occasionally in hyperphoria cases supra-orbital or ciliary pain on one side is present, but it is doubtful whether this can be due to the muscular deviation alone. In this form of heterophoria congestion of the eyeball accompanying low grade conjunctivitis is more apt to occur than in other forms, and it is more likely to be present in those cases occurring with oblique astigmatism; the conjunctival trouble is made worse by caustics and astringents, and is often in literature grouped with cases described as gouty lids, or in some instances among cases of spring catarrh as an atypical type in which the

anatomical signs of true Saemisch's catarrh are absent.

The marginal blepharitis which occurs in some cases of increased lacrimal secretion is due to irritation from the discharge, which runs over the edges of the lids by day, when they are open, and also at night because there is a predisposing anatomical condition in blepharitis cases, consisting of a shortness of the vertical measure of the lids, compared to the horizontal length, which prevents proper closure at night. This fact, which has been strangely overlooked by recent writers on lid inflammations, was fully proven by Fuchs and can be verified clinically with great ease; the lower edge of the cornea even may be exposed at night, and ulcerations in this situation may sometimes be rapidly cured by a night bandage, while resisting other treatment. It is by consideration of the shortened lids that we understand why relapses occur when ointments are no longer applied in cases of blepharitis marginalis, and why correction of the refraction or a muscular defect may sometimes permanently improve the condition by decreasing conjunctival congestion and lacrimation.

In hyperphoria hyperesthesia retinæ and some nervous irritability are apt to be present. A sign which should always excite suspicion of hyperphoria is a tipping of the head toward the shoulder.

The head is tipped downwards toward the right shoulder in most cases of left hyperphoria and some of right hyperphoria; in other cases of the latter anomaly it is tipped toward the left shoulder. The cause of this tipping is not entirely clear; on first thought it would seem as if it might occur in order to bring the eye with the higher image more nearly on a level with the other, but this fails to explain all cases. It should be remembered that men are in the habit of tipping the head toward the right shoulder in aiming rifles, and also in sighting lines and objects in many occupations; the right shoulder is lower than the left in right-handed people, and I believe that the sterno-mastoid and other muscles on the right side of the neck and head are also more powerful. May not the position of eyes and head be sometimes due to a common cause ?

The right ear is usually lower than the left and consequently spectacles sag downward on this side; eye-glasses having chains attached to the right lens also sag in the same direction. That vertically decentred lenses are a common cause of hyperphoria I have little doubt, having known it to occur from a misplaced glass, in cases where there had been orthophoria, and disappear after the glass had been straightened and worn correctly for a time; on the other hand there is a connection in some cases between the position of the glass and the hyperphoria

which is due to a displacement by the patient in order to correct the deviation and obtain comfort. I examined at one time glasses made by leading opticians and found about one half with the optical centre of one glass above that of the other; there is very much variation in the number of these errors between different manufacturers; glasses of a pair made at different times, as when a broken glass is replaced, are more apt to be incorrect in this way.

Another certain cause of hyperphoria is muscular anomaly, which may be a paresis or an excess. Take a recent case in which I found right hyperphoria of 5. manifest, 2. latent; right sursumduction 10., left sursumduction 2. ; myopic astigmatism .5 right eye, .25 left ; axis of glass 135° and 60° respectively. The left eye seemed to lag behind in upward movement of the eyes, and there was diplopia in the left upper quadrant of the field; insistent questioning regarding diplopia brought out the statement that the patient thought that she remembered seeing double about three years ago. This appears to be a case of paresis of the left superior rectus, though why a healthy woman of forty-six years should have developed paresis of an isolated muscle is a mystery. Investigations upon injuries to the eyes during childbirth may throw light upon the etiology of this class of cases as it is now doing with congenital amblyopia. Another test of

the muscles of a woman of fifty-six years with 0.75 D's of hypermetropic astigmatism against the rule in one eye, 1.50 in the other, and orthophoria, showed that divergence varied from 10. to 14., convergence from 13. to 16., right sursumduction was 4., left sursumduction 11. This seemed to be a case of excess of the left superior rectus.

Assuming it to be evident that low degrees of hyperphoria may be due to misplaced glasses and high ones to muscular defect, I think I may add one more positive cause for its production. I have found a number of cases with the right eye functionally or optically stronger than the left, in which left hyperphoria first appeared only upon convergence, then became manifest with fixation lines laterally parallel. This I believe to have been due to the fact that the right eye not only converged more strongly than the left, but also that the depressor muscles of the cornea were stronger; that it tended to go below the left first upon convergence, then permanently; I am sure this is the mechanism in some cases of convergent squint with sursumvergens, and although the squinting eye deviates upward it is really because the other went below it in the first instance.

The other causes now to be given to account for hyperphoria I consider rather speculative. The first is that when eyes are on a different level the muscles

become abnormal by attempting to bring the visual lines on a horizontal plane; this may be an occasional cause, as the two conditions coexist; yet if there is orthophoria, hyperphoria is not caused by tipping the head, in the few cases that I have studied in order to note the effect of difference in level of the eyes upon the ocular muscles, which brings us to the connection between hyperphoria and wry neck. In hyperphoria the head is inclined to the side with a twist, the base line (between the centres of rotation) sharing in the inclination; in the limited observations of spasmodic wry neck I have made, there was a more or less successful attempt to adjust the eyes (having no hyperphoria) by bringing them up on a horizontal line by giving a compensatory twist of the head away from that of the neck.

The head tipping in hyperphoria causes lateral curvature of the spine; the mechanism is perfectly apparent; I have seen such cases, and I think they occur somewhat frequently. The present methods of keeping a child's head straight in school work, and the introduction of vertical script do not meet the conditions in hyperphoria any more than in certain cases of astigmatism, and may in some instances result in the very troubles they are intended to prevent.

The next speculative consideration in the production of hyperphoria is optical. That anomalies of

the elevator and depressor muscles of the eyes may change the axis of astigmatism by a rotary action of the cornea in some instances may be true, but that does not account for the production of the hyperphoria. I have looked over one thousand cases tested for refractive and muscular errors in the last three years and find 465 (46.5 %) with oblique astigmatism; all other refractive errors 535 (53.5 %). By oblique astigmatism I mean with the axis not exactly vertical or horizontal, and the above proportion is about what I have found in my cases for many years. If the cylinder gives no better vision at an oblique axis than when straight, or than a spherical, the case is not counted as oblique astigmatism. Hyperphoria occurred in 20.8 % of all cases; in the oblique astigmatic cases 26.6%, in the others 14%. Hence there is evidently a connection between an oblique axis of astigmatism and the production of hyperphoria. There were nearly double the number of hyperphorias in women that there were in men, but as the proportion of women to men was not much less than that, the percentage may be considered nearly equal. In women right hyperphoria occurred in general more often than left by about 20%. In oblique astigmatism it was rather more frequent by comparison than in other cases. In men left hyperphoria was more than twice as frequent as right, in refractive errors other than oblique astig-

matism the proportion being more than 2.5 to 1. The explanation of the more frequent occurrence of left hyperphoria in men has been already touched upon. Men are more right eyed because of their habits and training than women (about half of whom are so binocular that they cannot wink), and have more tendency to depress the right eye. If men and women with better vision in the left eye, and women with equal vision in the two eyes are eliminated, the proportion of left hyperphoria to right perceptibly rises; this is even more apparent if left-handed persons, who use the left eye in shooting, are also left out of the count. It is perfectly evident from a study of these cases of hyperphoria, leaving out the purely muscular cases, which may or may not cause torsion of the vertical meridian, that there is a class of cases caused by oblique astigmatism. There are three ways in which this may be explained; first by inco-ordination of muscular action; second, by an attempt on the part of the rotating muscles to change the axis to a better position; this latter explanation seems plausible until it is applied to the cases singly, when it is seen to be inapplicable to many. Some of these hyperphorias disappear with the proper correcting glasses, and the disappearance is not always due to prismatic action, although this is hard to eliminate; a third way to explain the combination we are

considering is to suppose that in some of these cases the muscles are normal, but the vertical deflection of light caused by difference in the height of the corneal centres gives the vertical displacement shown by the test, which is optical, not muscular. This idea has a practical side, which is that oblique cylinders can be sometimes adjusted so as to cause hyperphoria to disappear, and that accuracy in finding exactly the proper axis of a correcting cylinder is an important consideration.

Latent muscular trouble is like latent hypermetropia. It is that portion of the ocular error which the observer fails to find; what is latent at one time to one man is manifest to another under other conditions. When the amount of hyperphoria equals the difference between right and left sursumduction it is usually all manifest; when hyperphoria is less than this difference, there is probably some of it latent, which is likely to become manifest later. This sounds correct, and has proven so to my mind, but it presupposes a diagnosis of hyperphoria, which is not always easy to make. It is my purpose to present as nearly as possible a composite picture of the more frequent and ordinary weaknesses of muscular action, since neither the writer nor reader could stand a detailed statistical description of some thousand cases; an occasional history to emphasize the rule by showing the exception, or to illustrate

the occurrence of what is frequently denied to exist, seems to be indicated. I used to share in the sneers of my medical friends regarding latent hyperphoria even after being convinced of the frequency and importance of the trouble itself. In June, 1892, a boy of thirteen years who had been under the care of a careful and competent ophthalmologist and fitted by him two years before with sph. $-.5 \supset$ cyl. $-.5$ changed to me as a matter of convenience. Under atropine I found myopia of 2.50 with myopic astigmatism of 1. in addition, vision $= \frac{20}{30}$; there was orthophoria with prism convergence at 20 feet of 16., divergence 7. A diagnosis of slowly progressing myopia with congestion of the choroidal and conjunctival vessels was made and some asthenopia which was present seemed natural under the circumstances. Although the myopia and astigmatism increased only about 1.50 in the next two years, still the choroidal condition in connection with it was held to fully account for the increasing hyperesthesia of the retina, and with changes in the nasal mucous membrane for the lacrimation and recurrent attacks of follicular conjunctivitis, which latter came on several times in the two years and were apparently successfully combated with astringents, although treatment of the nose was instituted during one attack before it began to yield. Vision by this time hovered about $\frac{20}{40}$, being usually rather below this,

and the headaches and eye weakness had increased so that the boy was kept out of school and not permitted to go into business. Twenty-seven months after I first saw him he came into my office suffering from an exacerbation of his trouble, which was by now pretty constant as regarded lacrimation and severe headache, and as he attempted to look at me with his congested eyeballs some sort of a chemical change occurred in my memory cells which insisted to me that there must be hyperphoria here. A test with the Maddox rod showed $1\frac{1}{2}^{\circ}$ (old style) of right hyperphoria, which is usually more potent for mischief than left hyperphoria. A little coaxing brought out 2° the next day, and prisms of .75 were ordered in each eye, base down right eye, base up left, with the sphero-cylinders as before. The result was cessation of headache and decreased conjunctival congestion and lacrimation almost immediately; the patient read $\frac{20}{30}+$ with either eye one week later and went into business; had one headache in a year, but found that he had fever at the same time and went to his family doctor. In eighteen months all elements in the glass were slightly increased in strength, the prism now being 1. o. u. Two and a half years after this, September, 1898, the eyes began to be uncomfortable again, and examination showed V. $= \frac{20}{30}$ with sphero-cylinders slightly increased in strength, right hyperphoria

3.50. In the glass ordered prisms were increased to 1.50 each and the patient told that should his headache return after a time an operation would be indicated, as stronger prisms would not do as well as the others. I have heard of the patient once lately and he was reported comfortable. This is a case of hyperphoria which had been latent to me; to some men all hyperphoria is latent.

There is some interest taken in the usual course of hyperphoria; it shares with some other things a tendency to appear or disappear, increase or decrease or remain stationary. It usually increases, and I doubt whether the high amounts ever disappear without operation, unless they are caused by transient paresis of an ocular muscle.

Hyperphoria of .25 should, I think, be ignored, and I wish I could say the same of hyperphoria of .50, but this causes occasionally some trouble, depending upon the sensitiveness of the patient and weakness of sursumduction; thus, if sursumduction shows respectively 1. and 1.50, a deviation of .50 is apt to cause discomfort. Larger amounts are potent sources of mischief until among the higher grades some of them become strabismus sursumvergens and muscular asthenopia becomes improbable. It is well to correct the manifest hyperphoria entirely with prisms, or only leave .25 or .50 uncorrected, up to an amount of 2 Ds. From 2.50 to 3.50 or above from

three fourths down to two thirds may be corrected. In hyperphoria of 3. and upwards it is better in general to operate, but it is often convenient to try prisms in order to note the effect and convince the patient of the necessity for operation when more hyperphoria becomes manifest, as it is likely to do in a year, more or less. If manifest hyperphoria of 1. or less is to be corrected, I order the prism over the eye with poorer vision, and in cases with equal vision over the left. This leaves a chance to change only one glass when increased prismatic correction is indicated at a later time. Correction of 1.50 or over it is well to distribute between the eyes, base down over one, base up over the other, unless the deviation is decidedly limited to one eye. Other indications for varying the position of the prisms are limitation of upward or downward movements, use to be made of the glass, and other minor considerations. Take for instance the common condition of left hyperphoria with 1. of hyperphoria with the rod over the right eye, 1.5 when it is over the left eye. In this case the right eye is more used to fixing, and were it a case of squint the left eye would deviate. A prism of 1. base up right eye in such a case would be likely to cause more difficulty when first worn than one of 1.50 base down left eye, for obvious reasons.

It is easy to demonstrate the necessity of vertical

prisms in many cases; if the prism correcting the hyperphoria is placed over one of the glasses correcting the refraction, then reversed, most patients can tell which direction is comfortable and which distressing without any hypnotic suggestion.

It is usually presupposed that there is an error of refraction to correct in considering the ordering of prisms. If no correcting glasses are needed it would be better to operate in suitable cases, as many patients cannot be depended upon to wear glasses which do not help vision, even when symptoms are relieved by them. I have seen simple vertical prisms dropped in a case of hyperphoria because the headache was better; two years later the child affected was under treatment for lateral curvature of the spine. The headache returned after a time but the glasses seemed if anything to make it worse; inquiry showed that one prism had dropped out of the frame and been replaced with the base in the same direction as the one on the other side. This sort of thing is of frequent occurrence and produces curious consequences. A patient of mine aged eighty-two had hyperphoria of 3.50 and had suffered all her life from severe and frequent attacks of headache, with nausea and vertigo; measures for her relief had proved futile, the condition being described as " very bad for the last thirty years." I introduced prisms into the corrections for hyper-

metropia and presbyopia (+2.75 and +5., with which latter glass Jaeger No. 1 could be read up to 8″), which were about the same as were then being worn. Two months later the old lady reported with great delight that her headaches were relieved. Three years later this patient returned with evident senile hebetude, and upon being asked about the headache said that the relief had been only temporary; it turned out that she had dropped the glasses for distance, and when told that such a course had caused the return of the trouble, was very positive that she did not need any distant glasses, as she could see well enough without them. Spherical +6. was ordered for near work, with prisms, and energetic orders given that the distant glasses should be worn. This energy was not thrown away, for eighteen months later the patient again appeared with glasses on and said that her eyes were troublesome still; the young lady who now accompanied her corroborated this by saying, "Yes, grandma's eyes are uncomfortable, and she does not see well either." The old lady was wearing constantly the +5. formerly given for near work.

Prisms are very successful in relieving asthenopia and headache when properly applied in hyperphoria cases, yet sometimes fail when the vertical trouble is secondary to a lateral deviation, or when with vertical and lateral deviations the latter is causing

the symptoms. Some ophthalmologists ignore hyperphoria altogether in corrections, while others always correct or operate upon it first, knowing the dire consequences which sometimes follow the opposite course. It is safer to correct the hyperphoria first in doubtful cases, and watch the effect upon the lateral muscles; if the vertical deviation is small in amount proportionately to the lateral and only occurs with esophoria or exophoria as the case may be, and not in the centre of the field, it may safely be set down as secondary. In a case of hyperphoria of this type with severe and constant headache, which had remained after careful correction of the refraction under atropine and trial of various vertical prisms during a year, I took out the prisms, gave the less hypermetropic correction without atropine at a first examination, as there was exophoria, and the headache quickly subsided unless near work was done, then after a time entirely. My colleague of a neighboring city, who had been so carefully studying and treating the case before he came very properly to the question of operation, would be a little surprised, perhaps, if he knew how easily relief was obtained.

In considering the relative importance of the vertical and lateral deviations it may sometimes be advisable to order an oblique prism. I have this day seen a patient who was wearing a prism base out

over one eye, base up over the other. An easy way to figure an oblique prism is to take some unit of measure (as a centimetre) and draw a vertical line with the same number of units as the number which marks the strength of the prism desired to correct the hyperphoria. At the end of this line another at right angles is drawn with the number of units corresponding to the horizontal prism desired, then a parallelogram constructed. Keeping the direction of the prisms in mind, a diagonal line is now drawn from the corner where the apices would meet to that between the bases, which in the units of measure will show the strength of the oblique prism, and by its direction the axis. This oblique prism is the exact equivalent of the combination of the two others.

In operating for hyperphoria, tenotomy of the stronger superior rectus is usually done, for what seem to the writers upon the subject good and sufficient reasons. I have not as yet had to advance an inferior rectus except in cases of strabismus. In order to do the operation the eye is rendered superficially insensible to pain by cocaine or holocaine. I use the latter because it penetrates more deeply and has no effect on the circulation and pupil. There is apparently less secondary subconjunctival hemorrhage and œdema than from cocaine, but I have seen many more attacks of faintness following

its use than I ever saw after cocaine, so I incline to think it more toxic and have whiskey close by when I use it. After the eye is flushed with neutral salt solution the upper lid is supported by the ring finger of the left hand, which holds a pair of fine-pointed forceps between the forefinger and thumb. The little finger is understudy for the ring finger, the middle finger goes with the forefinger. As the eyeball is directed downwards the conjunctiva is grasped over the middle of the insertion of the superior rectus muscle, and with the tenotomy scissors in the right hand a cut is made. Through this the centre of the muscle tendon is grasped by the forceps and cut; from this laterally cuts are made, with the tendon grasped between the blades of the scissors, until orthophoria is obtained, the eyes being tested after each cut. A bandage should be worn, for comfort and to control hemorrhage, but a few hours; if the patient then uses the eyes the full effect of the operation may remain, or may be kept by forcing downward motion. The deviation may partly return, one third of the original being the most I have as yet seen come back, but allowance cannot be made for this without risk of over-correction. In this tenotomy there is usually a scarlet-looking eye by the second day, as the blood under the conjunctiva settles downwards on both sides over the sclera; the main trouble I have experienced from this

operation has been annoyance from the complaints concerning the red eye from patients and their friends. The fine-bladed scissors of Stevens I have had to give up after trials of several pairs; they tangle up in the muscle fibres and do not cut cleanly through them when the muscle is well developed, and considerable effect is desired, as in most cases upon which I operate.

CHAPTER III.

ESOPHORIA.

DESCRIPTIONS of that type of headache called migraine all need to be remodelled from the standpoint of recent knowledge of eye strain, and especially with reference to the type of headache occurring from esophoria. The only headaches of the "sick headache" type which are extremely unlikely to occur from esophoria are those in which gastric or intestinal disturbances of a marked type precede the headache, and this occurs in the form of very severe hemicrania; in this type of headache there is sometimes a suspicion of some stationary and chronic change in the bones of the skull, causing pressure or irritation of the brain, its membranes, or its blood-vessels, in which case paresis of an external rectus muscle may occur with the headache attacks. Possibly spasm of convergence may occur from irritation of the convergence centre in migraine cases, but it is rare. A good illustration of a form of sick headache not due to ocular anomaly may be found in cases of arterio-sclerosis; these

latter headaches increase with age and are to be differentiated not so much from the headaches of esophoria as from those of exophoria.

The regular history of the headache of esophoria, which is uncomplicated by other forms of eye error, is that it is periodic, and accompanied by dizziness and nausea. Its occurrence may be usually traced to prolonged use of the eyes in distant vision; thus it occurs after attendance at a theatre and is apt to be referred to the close air; after shooting at a rifle range, when it is supposed to be due to exposure to draughts of fresh air; after a course of art study or the like, when it is known to come from lack of exercise; after bicycle rides, when it is considered evident that it is due to too much exercise. During or preceding the attacks the latent esophoria is apt to become manifest, and in some cases, whether muscular or accommodative, homonymous diplopia may result. In most cases of headache from esophoria the trouble tends to diminish toward middle age as the interni become weaker and the refractive error becomes manifest; and this result is referred to all sorts of causes except the real one, which is spontaneous improvement or disappearance of the esophoria.

It must be kept in mind in all cases of heterophoria that there may be no symptoms at all (in which case the deviation requires no treatment,) or all of the

usual symptoms, or any combination of them. It has happened to me to observe much dizziness, with or without nausea, from esophoria, and more cases of vertigo in this than other heterophorias; in fact this and hyperphoria have so far furnished the few cases of vertigo with falling that I have seen relieved by eye treatment.

Accommodative Esophoria. Esophoria with Hypermetropia.— Esophoria is usually accommodative and due to spasm of convergence, accompanying spasm of accommodation, in uncorrected hypermetropia. When 1. or less it may be ignored except in cases of neurasthenic muscular asthenopia with weak action of the interni and externi; in rare cases esophoria of 1. or less may be due to false projection, the eyes converging for 20 feet and the mind projecting the images to infinity. In many cases of accommodative esophoria in young people the case may be diagnosed with ease. Divergence is not below normal, and when a proper correction for hypermetropia is put upon the eyes orthophoria or even exophoria and excess of divergence may immediately result, or develop after the glass correction has been worn for some time.

In view of the peculiar expression some ophthalmologists have at the mention of esophoria with insufficiency of the interni or excess of the externi, as well as the peculiar statements in some quarters

about the lack of effect upon convergence through the accommodation, let me present the case of a lad who came into my office a few days ago and saved me the trouble of deciding which of the many cases among the histories of such should be described, as I do not expect any other to present a more marked example of divergence excess and esophoria. The boy's age is sixteen, and +2.75 spherical is being worn. There is +4.50 of hypermetropia, and .50 of astigmatism in addition, with better accommodation in the right eye than the left. V. = $\frac{20}{30}$, R. E., $\frac{20}{30}$, L. E. At 20 feet there is an esophoria of 4.5, convergence 20., with forcing after instruction and practice 35., a little left hyperphoria with convergence. Divergence 15. The convergence near point is 5 inches, at which distance the eyes begin to diverge, although by an effort fixation can be recovered and the eyes forced to converge nearer. Exophoria at 13″, 4 D's. With full correction of the refraction there is orthophoria, divergence still 15., convergence not so good as without the glass. If I may judge by experience these eyes will have exophoria before long, and perhaps divergent squint later, although without proper correction of the refraction there is now periodic convergent squint which the patient has observed. These cases should be treated for the accommodative esophoria first by correcting the refraction, later for the exophoria and

excess of the externi by tenotomy of the latter muscles; always provided there is muscular asthenopia or the condition is passing into strabismus.

The diagnosis of accommodative esophoria is not always easy. As time goes on in these cases, if the refraction is not corrected, divergence becomes weaker and may be as little as 5., seldom lower. It may well be asked why divergence of less than 5. should be arbitrarily given as not belonging to accommodative esophoria when it is well known that convergent squint is often if not usually of accommodative origin. It seems to me that in cases where the desire for binocular fixation is so strong that it will allow esophoria only to result, and where the spasm of accommodation and convergence except for this desire would cause squint, the externi would hardly fall below a standard of power sufficient to insure binocular fixation, with a margin left for emergencies, unless they were insufficient; for practical purposes, divergence of 4. or less should be considered as a muscular insufficiency, unless convergence is also correspondingly weak, when the case belongs to another class to be considered later.

All cases of esophoria with headache, dizziness, or nausea after use of the eyes for distant vision, in which the muscular deviation does not yield to correction of the manifest hypermetropia, should (unless surely myopic) be put under atropine. In

certain young persons, with a moderate amount of hypermetropia and spasm of accommodation which entirely conceals the refractive error, there is esophoria with periodic headaches, accompanied by dizziness and nausea, which are relieved by correcting the refraction as shown under atropine less .25 or .50; after a time the esophoria disappears entirely and the glass is dropped without a return of the symptoms. A certain amount of the hypermetropia I consider the artificial production of the atropine; some patients may bear the full correction found under atropine, but more do not; if a correction is given which does not allow of clear distant vision after the atropine is no longer used, the patient, especially if still in the years of childhood, is likely to look over the glasses for distant vision and thus defeat the desired effect upon the muscles through the accommodation. The effect of accommodation upon convergence depends upon structural or educational connection between the centres in the brain, and is very variable in different people.

It may be of interest to know the slow mental processes by which the writer arrived at some of these conclusions which he has set forth. Under an able and thorough chief, during some years I tested the refraction of several thousand patients under atropine; as time went on and I found that the tests without atropine tallied with those found or

expected under atropine, the use of the drug was dropped. Certain cases did not do as well as regarded the asthenopia and headache as formerly, when atropine was used, and after finding that this resulted when the glasses were of no different strength, and after eliminating the question of rest to the ciliary muscle as an explanation, I found that this result was due in certain cases to the relaxation of accommodative esophoria, and began to use atropine in esophoria cases again, as I had always properly been taught to do in cases of convergent squint.

A few cases show more esophoria under atropine than before its use. Duane has explained that this is due to extra efforts of accommodation induced by attempts to contract the ciliary muscle. Reasonable as is this explanation, I am not prepared to accept it; long ago, in the case of a child with convergent squint, in which atropine increased the deformity, the mother told me that she had noticed increase of the squint when her child was excited or agitated, and that the girl had been very angry about the drops, the eyes crossing more just as soon as she knew that they were to be instilled. I have been able in the cases under discussion to trace the result to spasm of convergence, or weakness of divergence, caused by nervous irritability or exhaustion; within a few weeks I had this occur, my

patient, a neurotic woman of forty, being in a very excited state because the atropine had dried her throat and kept her awake; at the beginning of the examination under atropine esophoria had increased, but at the close when the patient's excitement had gone down the esophoria had decreased with it.

Cases of accommodative esophoria may occur up to the age of fifty-five years. In hypermetropic presbyopes with esophoria spasm of accommodation may be suspected when the glass required to correct the presbyopia is stronger than usual. In cases of accommodative or spasmodic esophoria operations are, of course, contra-indicated, although frequently performed. It is in just this class of cases that tenotomy of the interni does the most harm. If it is doubtful whether the case is accommodative or muscular, and symptoms are not relieved by mere correction of the refraction, prisms of just sufficient strength to bring divergence up to the minimum for that case (6. or 7.) may be given. It may be some years before relaxation of the interni in these cases causes the esophoria to disappear, but it usually occurs, sooner or later.

In accommodative spasm, as in any other spasm (if such exist) of the interni, strychnine, rest, and general tonic treatment often increase the esophoria and the ocular symptoms.

It would be very erroneous for any one to suppose that the typical symptoms of esophoria—headache, dizziness, or nausea, with a tendency to periodicity occurring after prolonged use of the eyes for distant objects—are usually met with unaccompanied by other ocular disturbances. In accommodative esophoria especially are there often other disturbances due to other ocular conditions; thus hypermetropia and astigmatism may cause frontal and temporal headache for distance and near work, and as in some other forms of esophoria, insufficiency of the interni, or of convergence, may cause asthenopia when near work is done, and intense and constant headache may occur when esophoria at the reading distance is present, which error may be greater than that for distance.

Esophoria of Habit. Esophoria with Myopia.—My attention was first attracted to this class of cases in June, 1894. A young lady of twenty-three years came to me with the statement that she saw double at times, and that all glasses given to her heretofore caused much dizziness and discomfort. There was myopia of 2.25 with a little astigmatism. Esophoria of 8. increased to 12. with the glass (2 D.) now being worn; convergence 25., divergence 5. 13′ esophoria 5., convergence 45., divergence \fter atropine no change in refraction, esophoria nvergence 38., divergence 6. There was

apparent divergence; especial note should be made of this; in myopia with esophoria there is apt to be apparent divergence and the glasses are often centred too broadly, while in myopia and exophoria there is usually apparent convergence and the opposite error ~~of too great an o.c.~~ in the glasses often occurs. Glasses were ordered in this case with prisms 1.50 o.u. base out and o.c. in proper position; in other words, 3 D's of prismatic action at the fixation lines. These glasses caused no discomfort from the first, but three months later the patient asked if she could not have a less clumsy glass, as the thick outer edges of the present one attracted attention. Esophoria was now 6. This was accomplished by making the p.d. narrower, the centre of glasses being 3 *mm.* inside the lines of fixation, and no prism ordered. Three weeks after this the left eye having a little neuralgic pain when the glass was worn, esophoria was found to be down to 2. without any glass, and also with the last glass. The discomfort subsided shortly after, and the patient brought in her mother, who had high myopia and convergent squint, the eyes converging for the far point of accommodation, which was $2\frac{1}{2}''$ from the root of the nose, and not diverging for distant objects. Convergent squint with myopia had before this excited my interest, and after concluding that it resulted from the habit of fixing near objects, I found that this explanation

and no other had been given by all writers who had considered its causation.

After this esophoria and myopia attracted my attention, and soon after I had an opportunity to treat two sisters with this combination; one had already had twelve operations done in the vain endeavor to straighten the eyes, the only result having been much fatigue to the nervous system; the other had long been troubled with dizziness and had been treated for "the liver" without relief to that symptom. In the latter case, as the decentred lenses ordered seemed to cause asthenopia, I ordered prisms for the same muscular effect (combined with the correction for the refraction, practically the same that was being worn before I saw the case), and the dizziness subsided slowly, disappearing within a month. It returned about three years later, when it was found that orthophoria was present instead of esophoria of 3., and the prisms of 1. base out were taken from the glasses, when the dizziness and asthenopia again disappeared. In the case of the first sister there was esophoria of 7., right hyperphoria of 1., and it is not necessary to narrate the details of the glasses decentred inwards, and the good effects, except to say that in three years the hyperphoria disappeared, as it was a convergence hyperphoria, and esophoria was 1. instead of 7. The father of these girls has hypermetropic

astigmatism and orthophoria, the mother has compound myopic astigmatism and no appreciable deviation, and another sister has myopic astigmatism, with a little exophoria and excess of divergence.

Since these cases I have treated several scores of others with myopia and the esophoria of habit, all in the same way. This includes cases in which I had formerly failed to appreciate the condition. As a rule convergence is not excessive, and there is sometimes asthenopia for near work from insufficiency of convergence; there is a fairly definite relation between the amount of myopia and esophoria; I decentre the glasses from 2 to 4 *mm.*, so that there is prismatic action at a distance with the prisms base out, and usually some prismatic action in the opposite direction for reading distance. This is not done at haphazard; the object is to get the least prismatic action that will cause comfort to the patient, in the expectation that improvement or cure of the deviation will result as the eyes become accustomed to fixing at a distance. The trouble occurs in persons who have gone with their myopia uncorrected in youth; the symptoms in some cases do not begin until glasses are worn, and may pass off without any especial attention to adjustment of the lenses, although not infrequently they persist. The most usual symptom is dizziness with distant glasses, occasionally headache, and I have seen one case of

conjunctival congestion and blepharitis marginalis. In this latter case a patient whose refraction had been corrected returned to me because of increasing eye strain. For the esophoria, which had previously been ignored, appropriately centred glasses were ordered. I had no chance to verify the correctness of their manufacture, and nearly a year later my patient returned, complaining that the glasses had done him no good. The feeling of strain and the lid trouble were worse, and I found that his optician had taken the liberty of correcting my error about the centre, or paid no attention to the directions; I saw that the lenses were decentred as I wished, after which the symptoms promptly subsided, and the lid congestion as well.

It will be noticed that a distinction was made in two of these cases between prisms and decentred lenses; I have given up any attempt to keep up such a distinction in clinical work, except for certain purposes, as when I find it much easier mentally, as above shown, to fit a decentred lens than figure prisms, or when, as in the case where vertical prismatic action is desired, I order prisms instead of decentred lenses because I find this method easier as well as more likely to insure correctness in the work of the optician. The decentred biconvex lens portrayed in books which state that such a glass is equivalent to a prismosphere is dissimilar to the

glass ground by the manufacturers when spheres and prisms are ordered in combination, as the latter has one plane surface and may be considered as a decentred plano-convex or concave lens. It is certainly wrong to consider such lenses as identical, or a decentred meniscus as the exact equivalent of either; the differences are not only optical, but prismatic as well when the eyes are turned toward the periphery of the glass, yet the pain in one eye caused in the patient above mentioned when prisms were replaced by decentred lenses should be referred to the different position of the weak oblique cylinder in the lens, or some optical influence, rather than difference of prismatic action. It is only by consideration of such points that reported cases of asthenopia relieved by toric lenses in place of the usual kind, or a change of frames for the glasses, can be given any value.

In muscular asthenopia we are dealing largely with subjective symptoms caused by variation in physiological and anatomical conditions; the conservative observer, until he or some member of his family suffers from severe muscular asthenopia, is apt to remain somewhat skeptical regarding the importance of these difficulties, to regard a necessarily artificial classification with some suspicion, and may question the propriety of the introduction of a separate class for cases which it might seem possible to

include under old headings by means of some elasticity of distribution; yet the myopic esophoria of habit has strong claims for recognition as a clinical entity; when it is recognized and considered in glass corrections it is easily treated and benefited; when not, the fatigue of the externi often continues and the symptoms may go on from bad to worse. The esophoria is out of all proportion to the weakness of divergence, and exceptionally may be increased by stimulation to the accommodation when concave glasses are worn. Thus it will be noticed in a test given above that esophoria of 8. increased to 12. with the correcting glass, while divergence of 6. remained unchanged. It will also be noticed that prism 1. only was ordered; I never order a prismatic effect in such cases which increases divergence to more than 8. no matter what the esophoria. I follow the same rule in all forms of esophoria, but in no other is there any such disproportion between esophoria and divergence after correction of the refraction as in the esophoria of myopia. It must always be kept in mind when prisms are ordered that the prism strength is added to the muscular power in the direction of the base and deducted from that in the direction of the apex.

Passing over a considerable number of these cases which present no special features it may be proper to present a case with a fairly complete history

which showed the deviation and its effect to a marked degree; in view of the astigmatic element in some of these cases it may be well to state that a considerable number had the condition, the symptoms, and the results without any astigmatism being found.

A hard-worked financier of forty-eight years had been ordered sph. — 9. right eye, — 8.50 left, in the spring of 1898, by a careful ophthalmologist of high standing. He had signs of nervous fatigue with some dyspepsia, but his most troublesome complaints were of headache, mostly posterior and basilar, and attacks of vertigo, without falling, when attempts were made to look at distant objects. His physician, having found no relief to his symptoms after a summer's vacation, concluded to resubmit him to an eye examination, and I saw him in October, 1898. Vision with the old glasses (62 *mm.* o.c.) was $\frac{20}{50}$ — o.u. With —9.50 and — 9. ⌒ cyls. — 1. and — .75 axis 90° in the right and left eyes respectively V.= $\frac{20}{50}$ + in each. The eyes without glasses showed an indeterminate amount of esophoria and convergence; divergence 1. and homonymous diplopia under a red glass. There was right hyperphoria of 1., but the natural sag of the glass corrected this. It was found that with the glasses at 56 *mm.* o.c. orthophoria was at least temporarily present, and they were thus ordered, a near glass less the presbyopic correction being ordered with o.c. at 60 *mm.*,

as convergence was weak. This was done without making unnecessary tests, as the already prolonged examination had pretty well exhausted the patient. The glasses caused much distress at first, but this wore off, and the vertigo and severe headache were relieved within a week. Nine days later the eyes with the glass on showed for distance orthophoria, with convergence 20., divergence 7. It is well to note that the prismatic action of the glass upon the eyes was 4., and also to call attention to the fact that the hyperphoria was no doubt one cause for the inco-ordinate action of the muscles of the eyes without glasses, and perhaps had a contributing influence in producing symptoms; as to the astigmatism as a cause of the vertigo this was thrown out, since a duplicate pair of glasses were made later by the patient's optician at 60 *mm.* o.c. and they brought back the vertigo quickly; another similar mistake was made later, with the same result. When the eyes (or externi) were fatigued, as after attendance at theatre, the esophoria partly returned with a feeling of ocular fatigue, and about 2. of esophoria could be found the next morning (with the glass worn). This patient had clonic blepharospasm on the left side and I treated his conjunctivitis and blepharitis; when this failed to relieve the twitching, as a little more astigmatism had become manifest in the left eye, I ordered a cylinder .25 stronger for

that eye. In June, 1899, the patient returned, as he had begun to have some increasing discomfort from his eyes, and he had been warned to expect that as his esophoria disappeared; he reported that his blepharospasm, headache, and dizziness had remained away after the last glass was worn, and his ability to read without fatigue had gradually improved. I found hyperphoria 2. (1. being corrected by the glass). With the glasses on there was now exophoria of 2., divergence of 10. New glasses were ordered at 60 *mm.* o.c. with vertical prism 1. (base up, left eye), and the patient told to report if not entirely comfortable. This case is the only one seen by me, except the first one mentioned, in which periodic squint with diplopia occurred and the only one in which hyperphoria increased during the time the case was under observation.

Full correction of the refraction is indicated to give the best distant vision and stimulate proper binocular fixation at a distance, and operations are contraindicated in the esophoria of habit, which occurs always, or nearly always, with myopia.

Muscular Esophoria.—Esophoria from muscular causes is due to excess of the interni or insufficiency of the externi, and may occur with any or with no error of refraction. In the first condition convergence is powerful, divergence may be secondarily somewhat weak, nervous irritability or strychnine

increases the defect, and there is esophoria also for near points unless insufficiency of convergence coexists. It may have been noticed that a distinction is made between insufficiency of the interni and externi, and insufficiency of convergence and divergence; by the first terms I mean that there is a muscular defect, by the latter a deficiency, shown by the tests, of an associated action, which may be muscular, nervous, or secondary to an error of refraction. For instance, insufficiency of convergence may be due to optical, accommodative, or general nervous causes, excess of the externi, fatigue, or insufficiency of the interni. Whether the oft-mentioned spasm of convergence occurs without excess of the interni, or insufficiency of the externi, except in general disease, as meningitis, hysteria, or chorea, or from local conditions, as from hypermetropia, hyperphoria, or improper glasses, is somewhat doubtful. There are rare cases which show good balance of the ocular muscles and normal divergence at times, which at others show esophoria and weak divergence. Probably these are mostly instances of latent esophoria becoming manifest, like the other more numerous cases in which esophoria is increased under just such general conditions. It would be as rational to refer them to exhaustion of divergence as spasm of convergence, the excess of convergence being simply a secondary result.

In cases of esophoria and excess of convergence it is well to treat the deviation with caution, especially when hypermetropia coexists, using atropine and attempting to relax the interni; over-correction of hypermetropia, or convex glasses for reading in non-presbyopic cases, I do not particularly favor, although the latter plan may sometimes be followed with benefit. Prisms do well in the proper cases; those in which the insufficiency of divergence and the esophoria practically agree, and the muscular condition for far and near are similar and prisms of from 1. to 2. over each eye nearly correct the difficulties. In such cases three fourths or even all the deviation may be corrected, the prism being ordered in combination with the glass properly correcting the refraction. In cases where the deviation tends to increase, and prisms having been of relief are so no longer, a tenotomy of one internus, perhaps followed by a tenotomy of the other later, may be indicated. The operation is similarly done to that for hyperphoria, but usually needs to be complete. In these operations strength is sacrificed for position, convergence is usually weakened for a time out of proportion to the good effect upon the esophoria, and near work is apt to cause considerable discomfort for a week or two at least, even when the operation was done delicately. After this the severe headache and symptoms are likely to be relieved,

and although from the nature of the anatomical conditions the esophoria is prone to return, weeks, months, or years later, the headache and other symptoms may not return. I am not conscious of reason for regret in having done this operation in the few cases in which I thought it necessary, but I have treated a considerable number of post-operative cases after they had passed out of the hands of colleagues, and I am not highly enthusiastic about the results.

Most cases of muscular esophoria are, in my opinion, due to insufficiency of the externi. Strychnine sometimes will help the asthenopia in these cases; divergence is 4., or less, and convergence is not excessive. The proper operation is an advancement of an externus, picking out the weaker if this can be done, as is often possible. The usual advancement for insufficiency is a detachment of the central part of the muscle from its insertion, loosening of the subconjunctival tissue toward the cornea, and the tightening and tying of a single horizontal stitch which is passed through the middle of the muscle near its cut end and the tissue above the sclera up to the corneal margin. This single stitch is entirely effective for the readvancement of a tenotomized muscle when the effect is too great, but for cases where the opposing muscle is strong I prefer to lift the muscle upon a tenotomy hook after making a

small opening above and below, and then pass the needles at each end of a stitch through this upheld fold toward the cornea, grasping conjunctiva and muscle in a loop which holds more than half the breadth of the muscle. The stitch is tightened, and tied when orthophoria is obtained; the result is certain and permanent, and no bad result follows should the stitch cut through, as it may occasionally after some days. The operation is easy and painless, and the fold in the muscle disappears gradually, leaving the effect of the operation with no deformity. Notwithstanding the good points about this advancement it is not likely to come into general use, as it is not so picturesque as some others at the time of and immediately following the operation. The stitch of an advancement should be kept in place for five or six days, the eye being kept bandaged. Motions of the eyes are uncomfortable because of the stitch, and are avoided by the patient while it remains in position, so I advance, or, strictly speaking, fold, a muscle in my office, using no speculum, and let my patient go home with a single bandage. It is absolutely necessary to test the eyes at intervals while doing tenotomies and advancements for heterophoria, and this cannot be so well done if the patient does not sit up for the operation in the office. I find confinement in bed unnecessary.

It will be seen by the above that the old motto

"It is better to be sure than sorry" applies to the treatment of esophoria. I am in no greater hurry to operate in these cases as time goes on than I was formerly, and I am constantly surprised by the improvement in, and disappearance of, certain esophorias without operation where such a result could hardly have been predicted. Any contra-indication will deter me from operation in these cases, and I will here mention the case of an ophthalmologist who had suffered severely for ten years from extreme asthenopia and headache, mostly temporal and frontal. This gentleman had consulted colleagues in various cities about his ocular muscles and the last one had proposed to straighten his physiological vertical meridian, which tipped a little; this last opinion immediately gave me a clue, as I had seen such cases before. The patient was wearing + 1. and 1.25 cyls. axes 90°, which he had fitted, and which all the consultants had accepted without special investigation, and he had astigmatism which was most perfectly corrected by cyls. + 1.25 and 1.75, axes 85° and 100° respectively. There was decided vertical insufficiency of the lids, with conjunctival congestion and blepharitis marginalis. At twenty feet esophoria 2., convergence 16., divergence 4. At 13″ exophoria 10. and upwards, from convergence insufficiency; convergence 25., divergence 14. There was no hyperphoria, and I told him

that I was conscious enough of my limitations to let the muscles alone in all such cases as his, even if the symptoms were more indicative of a muscular cause than in this. I ordered the proper cylinder and told him to treat his blepharitis, for whether the compression theory be true or not, certainly asthenopia comes from lid irritation in some cases; advised strychnine to be used for the insufficiency of convergence and the effects noted. The latter treatment had of course already been tried. This physician followed the first two suggestions, and reported with apparent delight one week later, before he left for home, that he and his eyes had not been so comfortable for years. There was no change in the muscle test. It is doubtful whether those eyes now have the comfort and endurance that would be likely to be present in a case with strong, well-balanced ocular muscles, yet a moral of a certain sort may be drawn from the history.

It may be well here to call attention to the fact that occasionally cases with weak externi momentarily overcome prisms base in far in excess of those which represent the real muscular power, while rather more often just the opposite condition obtains in eyes with abnormally strong externi. For instance the externi may overcome prism 7. or 8. as the test is first made, yet, in case they are weak, diplopia quickly results should the prism be kept

before the eyes, after which it is found that weaker prisms are not overcome; on the other hand with strong externi prisms which at first produce diplopia are overcome soon after, and divergence may thus turn out to be much in excess of that which a rapid and superficial test would have shown. This tendency to concealment of latent deviations results from the very nature of the case; these eyes are not only forced into binocular fixation, but necessarily also in exercising that faculty into a condition which would be orthophoria if our tests should not succeed in relaxing the strain put upon the weak muscles. In measuring muscular ability endurance should be considered more than temporary strength.

CHAPTER IV.

EXOPHORIA.

THE headache of exophoria may only occur when near work is done, or is increased by near work unless there is divergent squint for near points. It may be frontal, general, or consist of pain in the posterior cervical region, and be accompanied by dizziness or nausea. There may be rapid exhaustion of the eyes for near work, with or without headache, from exophoria and weak convergence, and sometimes the symptoms may be produced by simple convergence for a near object or tests with prisms base out. This production of symptoms by prisms which bring a strain upon the weaker muscles is not confined to exophoria, but is more easily detected in this than in other deviations. For these reasons weak convergence was the first of the insufficiencies to be recognized, and has received an amount of attention not as yet accorded to the more obscure but not less potential muscular weaknesses. As will be noted above, the asthenopic symptoms in exophoria have nothing distinctive of the source,

since combinations of other muscular and refractive errors may cause them.

While divergence as an associated action has undoubted claims to a cerebral centre, yet I am positive that in normal conditions it cannot be forced beyond a well-known limit set by habit and the exercise of binocular fixation. I accept unqualifiedly the *dictum* of Hansen Grut that divergence of the visual lines cannot be produced at will and when found must result from abnormality, but that latent divergence is often concealed by convergence which exists both as a voluntary and reflex act.

Exophoria always means then comparative excess of strength of the externi, or of divergence (although not necessarily as a permanent condition), if we keep in mind the fact that the eyes tested at nearer points than infinity may not converge for the test distance. Thus for twenty feet if parallelism for infinity is present and fixation is for infinite distance, either through lack of accommodation in myopia or for any other cause, it will take about a 1. prism, base in, to produce vertical equilibrium. The men who originally stated that the difference between twenty feet and infinity could be ignored in testing the ocular muscles little foresaw that this would some time be applied to tests with weak prisms.

Exophoria of 1. at twenty feet I have often seen

occur in eyes where every other consideration led me to consider the action of the ocular muscles normal; more than that amount represents a real tendency to divergence, and with exophoria 1. only, manifest, there may be any amount latent.

Accommodative Exophoria.—Accommodative exophoria can only occur with myopia, unless it is produced by too strong convex lenses in hypermetropia, or is acquired in the same manner from reading glasses in presbyopia. In myopia the exophoria will only disappear in young persons when full correction is ordered, and in later life becomes permanent, although in an occasional case it yields somewhat to correction of the refraction in patients up to the age of forty and a little beyond it. There is of course no intention on my part to deny that certain anatomical conditions assist in the production of exophoria and excessive divergence in myopic cases. In cases of true accommodative exophoria there is likely to be little or no increase of divergence for distance, although prism convergence may not be up to the standard, while exophoria and weakness of convergence for near points are out of proportion to these conditions for distance. In fact it is the old, well-known condition of relative divergence.

These cases are so well known and have been discussed so often, that anything I have to offer may

be briefly stated. To prevent exophoria and insufficiency of convergence in myopia the refraction should be fully corrected; at a later period full correction, the glass being worn all the time, will give stimulation to the convergence and favorable prismatic action for near work. Fortunately this class of cases are not troubled much with muscular asthenopia unless there is an evident muscular defect for distance which admits of operation, an astigmatism which admits of correction, or nervous exhaustion of convergence power which needs appropriate general treatment. Perhaps the following will serve as a fairly typical case of accommodative exophoria. An athletic schoolboy, aged fourteen at the time of my first examination, October 1, 1898, had $\frac{20}{70}$ o.u., with sph. — 1.25 ⌒ cyl. — .5 axis 105° R., sph. 1.50 L. = $\frac{20}{20}$. Exophoria 3., no asthenopia. Further examination of refraction and muscles considered unnecessary. The glass ordered was only worn in the schoolroom, and on December 22, 1899, the myopia had increased to 2.25 o.u., with astigmatism as before in the right eye. Exophoria 4. As I supposed this to be a good sample case of accommodative exophoria the muscles were further tested in order to give the tests here. Convergence at twenty feet, 12., easily brought up to 25. as soon as the patient was shown how to converge; divergence, 7. For 13″, exophoria 10., 12., or more; a

test for the near point of convergence showed fixation at first at 10″, but when the patient was told to fix his attention and turn the eyes in for the pencil he had no difficulty in converging to within 3″ and holding the eyes in that position. Cases of this sort are, in my opinion, exophorias without muscular insufficiency; they are more likely to have muscular asthenopia from overwork than those cases of myopia in which the eye muscles become more correctly adjusted to the new accommodative conditions, unless binocular fixation for near objects is sacrificed.

The production of accommodative exophoria by means of convex glasses is a common occurrence and can in many cases be avoided. It frequently occurs from full correction of the hypermetropia found under atropine, and over-correction of hypermetropia of about .50 in cases in which atropine has not been used is of no uncommon occurrence. Patients sometimes accept an over-correction of about .50 when hypermetropic, especially if after each eye is tested separately the highest correction is forced with both eyes open, the test letters with the glasses perhaps appearing somewhat faded or washed out, although vision is not diminished. I have in this manner occasionally succeeded in getting a stronger glass to correct hypermetropia than could be obtained later with the eyes under atropine. Another

class of cases in which accommodative exophoria occurs are those in which (perhaps under atropine) the spherical lens which represents the meridian of greatest hypermetropia, is accepted with vision of $\frac{20}{30}$, or so, while the addition of a weak concave cylinder would give better vision. In other words, there is a small amount of astigmatism, and the spherical over-correction given results in an artificial myopic astigmatism. I have noted several cases during the past year in which exophoria was produced or increased by over-correction of hypermetropia and prisms base in had been added to the glasses for the refraction, the total result to the exophoria being an increase; these cases had asthenopic symptoms which were often relieved when the convex lenses were made weaker and the prisms removed. Analysis of the results in such cases show them to be in part due to mental causes connected with the difference in vision, in part to refractive causes, and hence the effects of the difference in correction take on an exaggerated aspect if referred to the muscles alone. In the case of a physician with a little exophoria, who gave up medicine twenty years ago because he found no glasses to relieve his asthenopia, and who had been much better with the last glasses ordered for him than any previous ones, the first glasses (for he had saved them) turned out to be convex cylinders .75 and .50 fitted under atropine;

the others were given on the same principle, except the last, which was a concave cylinder, opposite axis; this patient has since been able to use his eyes freely and comfortably with treatment for the muscular error. In cases in which the effect is out of all proportion to the cause it is safe to refer something to the imagination of the patient.

Accommodative exophoria from glasses also occurs in presbyopic cases, and although the principles in connection with accommodative exophoria as first laid down by Donders for such cases cannot be successfully attacked, if any man expects to satisfy his presbyopic patients by any attention to detail in their glasses he will find himself sadly disappointed, if he is alive to the results. Many of these patients demand one glass with which they can see at far and near points, and may consider an oculist incompetent or obstinate if he fail to satisfy what they consider a reasonable request. Convergence power is usually weak in presbyopes; convex glasses increase this weakness by their effect upon the accommodation, and are usually centred too broadly, adding an adverse prismatic effect to the other difficulties. If muscular asthenopia already exists from weak convergence the glasses may be centred in for a near reading distance, but if the object is to avoid asthenopia from glasses it will be safer to centre them for the far point at which they may be used, since

it is easier to exercise convergence than divergence, for evident reasons. Thus suppose a glass of + 2.25 about 15 *mm.* in front of each cornea or 30 *mm.* in front of the centre of rotation, with a base line of 60 *mm.* It would be safer to centre these glasses at 60 *mm.* $- \frac{60 \times 30}{450}$ *mm.* = 56 *mm.*, *i. e.*, for their far point of 18″ or 450 *mm.* instead of nearer, so as not to increase the asthenopia caused by looking off through them, of which there is usually so much complaint. Glasses for near work may be centred by sighting, in a similar manner to those for distant vision.

There is one point in addition to those which have received attention elsewhere concerning bifocal glasses, and that is that the principal complaint concerning these glasses is of the distortion of objects and diplopia at the upper part of the junction of that portion of the glass used for distance and the paster. While the formula for proper centring to prevent this prismatic action depends upon the distance of the upper edge of the paster from the geometrical centre of the whole glass, and is tedious to work out mathematically, it is a comparatively easy matter for the manufacturer to cut his paster so as to neutralize prismatic action at its upper edge. I have had no complaints and seen no bad results due to the symmetrical prismatic action of glasses of equal strength decentred upwards or downwards. It takes more knowledge than I possess to

successfully meet the demands of anisometropes who desire comfortable non-distorting bifocals.

There is no definite agreement regarding what should be considered normal balance for the ocular muscles at a near point, such as the reading distance. Among healthy young adults with good muscular strength and no particular refractive error, who do not unduly use their eyes, as soldiers, orthophoria is the rule at near points up to 12″ or less. This is indeed the best condition, yet is found only exceptionally among patients applying for eye treatment, with whom exophoria is the rule; while exophoria at a near point may easily occur simply from relaxation of convergence and accommodation, I regard exophoria of over 2. at 13″ as a sign of probable weak convergence, and feel sure that eyes with more dynamical divergence than this are usually more or less asthenopic from weak convergence. In this I differ from some other observers, who regard 4. or 5. of exophoria at reading distance as having no significance.

Much has been said regarding the production of heterophoria by glasses, but nothing much about the cases in which the eyes are forced into equilibrium notwithstanding the adverse prismatic effect of a decentred lens, on the principle which causes normal muscles to readjust themselves to differences in the height of the eyes. The following case is an

example of accommodative exophoria to which was added an adverse prismatic action of over 6 D's from decentred glasses, the whole error being rendered latent by spasm of the weak interni. A young lady with constant severe frontal headache, dizziness, which had lasted for years, and chorea, was wearing eye-glasses with — 5.50 o.u. in such a manner that a tight spring far forward on the nose brought the p.d. (and o.c.) at 2″, the base line being 2½″. V. O.U. = $\frac{20}{30}$. There was weak convergence for near points, but at 20 feet there was no appreciable heterophoria, convergence 14., divergence 7. Sph. — 6. at 2¼″ o.c. was ordered, and one month later there was esophoria 3., convergence 12., divergence 8. at 20 feet. Orthophoria at 13″ with convergence 30., divergence 14. The headache was no better and I began to doubt my diagnosis of exophoria and spasm of convergence from improperly centred glasses, and favored choreic spasm, or accommodative spasm from concave glasses, more than I had at first; however I persisted, and one month after the last examination exophoria of 2. with convergence of 30. and divergence of 10. appeared and the condition of the eye muscles has changed but little since; the headache became better at this time, and each time it began to reappear the glasses were ordered with o.c. 3 *mm.* farther out. The last order, eighteen months after the first, was with the

o.c. $2\frac{5}{8}''$. Divergence was then 11. with an exophoria of 3., and with the glasses 1.50 of exophoria still remains; the headache has not returned during the year and a half since then, and as choreic movements of the head and neck have disappeared, or greatly diminished, the correcting glass has not been further disturbed, or other eye treatment instituted in the vain hope of helping the general nervous difficulty.

The above points taken from the written history of this rather unusual case do not show the main reason why a diagnosis of spasm of the interni from misplaced glasses was made in the first instance, and I add from a clear recollection upon that matter that the orthophoria at the first test was shown without the glasses, with the glasses at 2″ o.c., or at $2\frac{3}{8}''$ o.c., with the same action upon accommodation, yet a variation of 6 D's of prismatic action. A side issue in the case was the demonstration of the fact that people cannot be expected to wear the nose-piece of eye-glasses in a position to which habit and the shape of the nose have not previously accustomed them; if a new position of the glass is desired it must be obtained by variation of the length and shape of the posts connecting the nose-piece with the glasses.

Muscular Exophoria.—Exophoria with insufficiency of the interni or of convergence will be

considered in the next chapter. Exophoria with excess of divergence can be diagnosed by the tests for the muscles at 20 feet. Divergence of 12. or more always constitutes excess, and from 9. to 11. usually. Convergence commonly decreases as age advances, and so soon as divergence excess with asthenopia is known to be permanent there should be a tenotomy of one externus, followed if necessary by a tenotomy of the other. This should be done on the principles already described, and in marked cases of excess needs to be complete, and not infrequently the attachments of the insertion loosened, to produce orthophoria in the middle of the field, with divergence of 7. or 8. A single tenotomy of an externus carefully done upon a well-developed muscle, care being taken to divide the tendon at its insertion and not loosen the attachments, will seldom give more than 5 D's of effect. As a rule the effect at the time of operation diminishes but little, if any, at a later period, if the cut muscle is put upon the stretch for a few days after operation by forced convergence; the most effective method of accomplishing this is to have the eyes converge for a near object, as the finger, several times a day, and once a day have this done while the eyes are armed with converging prisms; observations upon cases months or years after this operation show in general no more increase of

exophoria than usually occurs in the natural course of exophoria without operation. As a result of this operation, increase in the power of convergence is usually more than the decrease of divergence. There is less apt to be this increased convergence in myopic eyes, and in those where the muscles are poorly developed. In the following case increase of convergence was less than decrease of divergence, and it is the only one in which I have seen this occur. A poorly developed schoolboy of thirteen years of age, with myopia of 1.75, showed in December, 1896, exophoria 2., convergence 9., divergence 9. Nine months later exophoria 3., convergence 7., divergence 9. Tenotomy of the left externus was done and orthophoria resulted. Six weeks later there was exophoria 2., convergence 9., divergence 9. Three months later tenotomy of the right externus, resulting a week after in orthophoria, convergence 10., divergence 6.; one month later, exophoria .5, convergence 9., divergence 8. This condition has continued since, the severe headaches which the patient had after studying having been better, but, as general treatment including arsenic and strychnine has been used, it is doubtful whether the operations can claim any appreciable credit.

Another case of a similar character shows that so little result as this cannot be foretold. This was

the case of a man of twenty-five with severe and constant headache made worse by near work. He was of the same neurotic, ill-developed type, had compound myopic astigmatism, which had been carefully corrected one year before I saw him in April, 1898, and had exophoria 4., convergence 6., divergence 10. Tenotomy of the left externus gave but temporary relief as orthophoria only lasted a week; so one month after the first operation I over-corrected the exophoria by tenotomy of the right externus, attaining esophoria 2., convergence 14., divergence 3., changing to orthophoria with convergence 16., divergence 7., in two months. The proportions changed to 12. *versus* 8. nine months after the second operation, when the patient reported that he had only had a few slight headaches when he was tired and had overused his eyes.

In contrast to these let me give the most marked case of increase of convergence I have seen, in eyes with hypermetropic astigmatism of .50 in one eye and .25 in the other. A young lady of twenty-four years came to me in May, 1899, after a season of operations upon the ocular muscles done for the purpose of relieving her of extreme headaches, dizziness and nausea. She was wearing sph. + 1. with prisms of 2.50 base in over each eye for reading; exophoria of 5. at 13″ being increased to 8. by this combination. She had, at 20 feet, exophoria of

1 D. with the phorometer, 7. or more with the Maddox rod; convergence 20., divergence 20. I first tried correction of the slight astigmatism, and removal of the objectionable glasses, but with little relief, so three weeks later I divided the left externus; all the exophoria I could get after this by any test was 4., and the first result and that five months after varied only 1., convergence going to 38., divergence to 16. This improvement in the eyes and a summer's vacation gave no relief to the symptoms, although general tonic treatment had been kept up. I then divided the right externus, and the patient becoming exhausted and faint from a rather prolonged operation in her neurasthenic state, a free tenotomy left 2. of exophoria, although divergence was but 6. and homonymous diplopia was present on the right side of the field. One week later, as convergence improved, the result was esophoria 2., convergence 40., divergence 5. In one month, however, there was orthophoria for far and near with a convergence of 65., divergence 9., at 20 feet. The action of the muscles was now co-ordinate, dizziness and nausea had disappeared and the general headache with them; the distressing pain at the nape of the neck had not yet entirely disappeared, although it did soon after, the patient reporting herself well two months later and showing the same muscular condition as that last given. In this case reduction of

divergence 11 D's gave increased convergence of 45. A contrast to this as regards result to the symptoms before a good muscle test was obtained, yet agreeing as regards improvement in converging power, is shown by the case of a girl of nine years, who had crossed diplopia under a red glass, and in whom I did free tenotomy of the left externus, with the result that two months later while convergence for near work had improved, at 20 feet there was convergence of 2. only, divergence of 20. Eight months later there was convergence of 12., divergence 14. Severe and frequent headaches had disappeared since the operation. In these two cases post-operative hyperphoria was temporarily produced and disappeared in a week; a not very uncommon experience.

In contrast to these complete operations giving slight results let me say that I have a few times produced convergent squint and homonymous diplopia before an externus seemed to be completely divided, and have usually advanced the cut muscle with good result, by means of a single stitch tightened until orthophoria in the centre of the field was produced. In one case, however, the patient became hysterical about the stitch and promised faithfully to let me do anything I wished in the way of an operation later if I would remove it. As I wished to watch the effect, and the *onus* was on her, I left the muscle

as it was by drawing out the stitch, which had not yet been tied. There was, strangely enough, no dizziness following the operation, the headache which had not yielded to correction of the refraction, or other treatment, was relieved, and two months later the diplopia could not be obtained at the periphery of the field except by means of a red glass. A test four months after this showed orthophoria.

In case it should seem strange that readjustment should follow in some cases too little, in others too much operative effect, let me say that in the former class the exercises above described for a near point are used, while in the latter near work is prohibited for a time, but the eyes are encouraged to fix distant objects. This small detail of treatment would be of little use, except for the principle that people with strong desire for binocular fixation tend to force the eyes into orthophoria in the centre of the field, as soon as the muscular condition will permit of such a thing; let me say, however, that the above cases are for me the exception; in most of the others orthophoria was the primary result of the first operation. In such a case, if the effect decreases later, when a second operation is done I over-correct by an amount equal to the decrease which occurred after the first operation.

Exophoria of 4. or more with more than 12. of

divergence will usually require an apparently complete tenotomy. By apparently, I mean that it is difficult to cut across the tendon of a muscle without loosening the subconjunctival tissue, or the attachments of the muscle to the capsule of Tenon, through a small opening in the conjunctiva, and be sure of the complete character of the division, even when the line of insertion to the sclera can be seen; a small band of fibres, deep and peripheral, may easily escape notice. It should be remembered that the object is to remove the muscular difficulty, not to prove the division of a muscle. In weaker muscles tenotomies which only partially divide the tendon will produce results; as these cases are often of the neurasthenic type, I generally avoid operation upon them and cannot speak so definitely of them as of the class in which I find that division of the tendon nearly, or completely, in such a way as to avoid too much retraction of the muscle, is necessary to obtain a definite result.

It is by no means easy to tell in advance how much a muscle will retract, hence the necessity of graduating the operation by testing the eyes at intervals. Every competent operator uses this principle in cases of squint when he looks at the eyes to see whether he has advancement or tenotomy enough to reduce the deformity; in this case he is operating for appearance, in the other for muscular balance.

In exophoria cases it is well to take the desired strength of divergence as a guide in operating as well as the production of orthophoria.

It is very important to consider hyperphoria in its bearing upon exophoria and esophoria. The lateral deviations may improve or disappear when hyperphoria is corrected, or they may require further correction; the method already described of correcting the hyperphoria with prisms, then testing the lateral balance with the rod, also trying the effect upon convergence and divergence, gives valuable information but is not infallible.

Neurasthenia as a result of operations upon the eye muscles is not uncommon, from the nervous anxiety and traumatism, and it is well for the operator to get through by means of as few operations as possible. If the symptoms are no better after a couple of operations, it is just as well to inquire and determine whether a neurasthenic asthenopia is not replacing a muscular asthenopia, and treat the case accordingly.

CHAPTER V.

INSUFFICIENCY OF CONVERGENCE; NEURASTHENIC MUSCULAR ASTHENOPIA; INEFFICIENCY OF THE OCULAR MUSCLES.

IT has been a time-honored custom among ophthalmologists, to group all cases of asthenopia of which they failed to understand the origin as neurasthenic. In the United States a race of restless adventurous explorers, fighters of Indians and revolutionists, have, in the persons of their descendants and successors, taken to city life, books, physical appliances, artistic paraphernalia, steam heat, and other appurtenances of what they call education and civilization, with the same result that obtains when the country-bred boy settles down to sedentary city life—trouble with the digestion, circulation, and nervous system. The first attempts at imitating foreign civilization in this country resulted twenty-five or more years ago in the thin, pale, nervous young girl; as admiration for the civilization of France began to be replaced by imitation of the English style of life this type of woman began to

be replaced by the larger, stronger, rosier type in which forced development of the bones, muscles, and circulation was expected to properly adjust the balance in the forced brain and nervous system, with the result that nervous irritability with some energy and endurance began to give way to neurasthenia and emotional disturbances of the nervous system. In the first type by means of tonics, nourishing food, fresh air, and exercise we expect to meet the indications; if in the course of a generation or two the second is the result of this method, what next ?

The undoubted soundness of the view that attention to hygiene is the key to development of the nervous system as well as the other forms of tissue cannot be questioned; yet the occurrence of weakness in the ocular muscles with other undoubted evidences of lack of force, in the well-nourished and apparently well-developed American youth of today, show that nervous degeneration cannot always be successfully combated by a general knowledge that nourishing food, fresh air, and exercise tend to develop the human animal.

The main point to be insisted upon here is that a neurasthenic patient with muscular asthenopia is not of necessity a case of neurasthenic muscular asthenopia. The more neurotic a person is the more likely he or she is to suffer from nervous

symptoms referable to ocular defects, just as a case of chronic gastric catarrh has more dizziness and nausea from eye strain than one with better digestion. Occasionally muscular and nervous signs of exhaustion occur from excessive use of the eyes, with hyperesthesia retinæ and even displacement fields of vision, in persons who have not shown evidences of exhaustion in any other function than that of vision; as the exhaustion is mainly of nervous tissue of the eyes and their cerebral connections, these are properly to be considered as cases of neurasthenic asthenopia, although general evidences of nerve exhaustion are absent. Perhaps "neurasthenopia" would be a proper term for them.

The type of muscular weakness which belongs to the neurasthenic is that known as insufficiency of convergence, or defective amplitude of convergence; this latter term, with its positive and negative factors, is proper but formidable, and studies already made under this head are of little clinical value as regards diagnosis and treatment of heterophoria. I here take the liberty of proposing the term "Inefficiency of the Ocular Muscles" for the class of cases to be described; inefficiency means lack of power, or the desire for power, and exactly denotes the condition of weak muscular action arising from lack of development of muscles or of nervous tissue, fatigue and lack of energy, or want of ambition, which

characterizes neurasthenic muscular asthenopia. We often meet in the American youth of to-day and in others broken down by worry or illness, such conditions of the ocular muscles as follows: Orthophoria or esophoria 1. to 2., convergence 9. to 12., divergence 3., 4., or 5.; orthophoria or exophoria, 1. or 2., convergence from 6. to 8., divergence from 8. to 6. Fixation for a near point is weak and inadequate, with exophoria at 13″ from a few dioptries up to actual divergence of the lines of fixation. Sursumduction usually 1. or 1.50. This condition may be acquired, and if due to temporary general or ocular fatigue consist merely of a relative insufficiency of convergence, with little or no weakness or excess of divergence, and yield rather easily to ocular rest and general treatment with strychnine. More often the condition is permanent, both the ocular muscles and the brain centres being undeveloped, and I regard this condition as shown by inefficiency of the ocular muscles as one of the stigmata of degeneration.

Occasionally the apparent lack of muscular power is simply a sign of constitutional laziness and in such cases will not cause pain and discomfort; sometimes there is a hysterical element, more or less latent, and the muscular strength is variable. Variation in the power of convergence and divergence, except in cases of hyperphoria, or functional

or organic nervous disease, does not seem to occur to any extent in my cases of late years, perhaps because the routine tests are made over and over under the same conditions as regards the manner of testing, and with precautions against variation.

In neurasthenic subjects the weak ocular muscles, sensitive retinæ, irritable reflex centres, and generally inefficient muscular and nervous force cause undue susceptibility to slight physical variations affecting the eyes, while the cerebral condition is often such that general effects from slight local causes may be exaggerated, distorted, or imagined; in treating such cases, although the underlying principles are the same as in others, the point of view should change so materially that they must of necessity be considered as a separate class. For them the use of tinted glasses should be discouraged; the chemical rays of light, the most if not the only injurious ones to the eyes, do not penetrate glass to any extent, irradiation of light increases with refractive error, and hence correcting glasses are indicated if the patient's prejudices and nervous condition will permit glasses to be worn. Strong glasses may not be borne, even if they barely correct manifest error, and care must be taken to guard against strong or adverse prismatic effects. In a few cases in which operations seemed indicated to me I found the muscles ill developed, as might be

supposed from the nature of the cases and the results of tests for muscular power; such muscles may be badly injured by tenotomy and cannot be much strengthened by advancement. If lack of nervous impulse is the cause of the inefficiency, or it is due to temporary exhaustion of muscular or nervous force where the muscles are well developed, operations are surely not indicated. Since operations are of little or no use for the inefficiency, and may be harmful to the neurasthenia, they could only apply to the correction of slight heterophorias when such are present and cannot be successfully treated in some other manner; they would, therefore, be preferably postponed until general treatment has failed to relieve the asthenopia, and the general strength of the ocular muscles has reached a maximum.

It must be kept in mind that one form of insufficiency yet remained to be considered when we reached this chapter, insufficiency of the interni, or convergence, without excess of divergence, not accompanying hyperphoria, nor accommodative, and that this condition is neurasthenic and constitutes inefficiency of the ocular muscles. Although, as in the first case cited under the heading exophoria, it may be seen that advancement of the interni appears to be indicated, this operation at the best may cause too much post-operative annoyance to be appropriate to the neurasthenic condition, and we may

be compelled to confine ourselves, when an operation is justifiable, to cutting some fibres of a superior or external rectus for the correction of hyperphoria or exophoria, which would be more formidable except that in cases of inefficiency the operation is a slight one, complete division of the tendon seldom being necessary.

Extensive discussion of general treatment is beyond the province of this work. Strychnine is the general remedy most applicable to strengthen muscular and reflex action. It is given at first in small doses, then the dose is increased from time to time. It seems to me that in this manner we find just the dose that may be borne by a patient, not that we induce toleration for the drug. The remedy benefits some cases quickly, others slowly, others not at all; cases of orthophoria with insufficiency of convergence, due to fatigue from excessive eye work, do best with it, as previously stated; cases of esophoria with general nervous irritability do much less well. Certain general conditions are a contra-indication for strychnine, noticeably arteriosclerosis with high arterial tension.

Decision regarding the comparative merits and proper amount and character of rest and exercise in the general treatment of these cases requires much experience and nicety of judgment. It seems evident, however, that rest from that which fatigues or

irritates the nervous system, or rest to an overused structure or organ, would be, of necessity, indicated. It is hard for some of us to see any rational treatment for the eye with structural or functional weakness, suffering from symptoms brought on by strain of the weak part from overuse, not founded upon rest for the weary organ. Neuralgias in general are treated by attempts to improve the health and give rest to the painful part. Since the eyes are constantly in use when the lids are open, we are unable to obtain absolute rest without imperiling the general health; so we partially rest the ciliary muscle and meet visual and retinal indications by correcting the refraction, and attempt to give rest to the weak muscles by means of prisms, while we try to obtain a proper muscular balance by various methods. It is not the insufficiency which causes asthenopia but use of the insufficient muscles; insufficiency of the externi gives rise to headache with the most certainty when the eyes are used to look at outside objects from the windows of a moving train, while if no insufficiency exists for a near point the eyes may be used for reading, upon the same journey, without discomfort; reading from a prone position causes trouble especially, or solely, in cases of hyperphoria. In inefficiency the converging power suffers most; the condition precedes the asthenopia, apparently, as the weakness is congenital, or acquired from

worry, illness, or the wear and tear of surgical injuries or operations, in the latter cases the asthenopia and headache beginning after hard use of the eyes for reading, or other near work, during convalescence. Headache, dizziness, nausea, conjunctival congestion, and pain at the back of the neck are most in evidence with convergence.

Should it appear that we are indulging in an unnecessary amount of detail in order to show that rest is so important in the treatment of exhausted ocular muscles, it must be remembered that there was a time, perhaps forgotten by a younger generation, when a well-known American ophthalmologist instituted a treatment for asthenopia consisting of ocular gymnastics (and ointments for the forehead), which was received by some with great enthusiasm and expected by them to relieve all forms of eye strain not evidently accommodative; also, that forms of exercise for the ocular muscles are still in use with many statements on record regarding the increased strength obtained, as shown by tests and relief to symptoms. The first claim has been considered in an early portion of this work; as to the second, neurasthenia is essentially a chronic condition with intermittent symptoms, and statements regarding relief to symptoms are to be received with caution; they may, in fact, be a measure of the self-satisfaction of the man presenting them, or an expression

of an evident appreciation of his efforts by his patients, rather than an actual count of tangible results—which is well-nigh impossible to make in cases with subjective symptoms.

The general rule should be that eyes are not to be used for near work after they show the slightest signs of fatigue. When, as in my cases, tests for convergence bear a definite relation to the ability for near work, they may be used as a guide. Thus, with prism convergence of 8 D's for distance, the eyes are to be used at first not over five minutes twice a day, this time to be increased with increased convergence power, until with 16 D's the eyes are used for near work half an hour four times a day.

We have already noted the effect of emotion upon the ocular muscles, and incidentally it has been suggested that those emotions which cause excitement or irritability induce spasm of strong muscles, while those which cause exhaustion increase insufficiency; in this way latent heterophoria may become manifest, or pseudo-heterophoria may be produced. Nervous young women sometimes dread an examination of the eyes, and having a little asthenopia, are fearful that this signifies some dread disease. Fear not only dilates the pupil, but relaxes accommodation and convergence. This condition being limited in duration, certain cases which show inefficiency of the ocular muscles at a first test will show

improvement of convergence at a later period, without regard to treatment. The contradictory indications to be met in treating the asthenopia and convincing the patient that there is nothing the matter with the eyes, may sometimes require mental more than direct medical treatment.

When glasses are worn, especially convex ones, a new relation is set up between accommodation and convergence, and muscular asthenopia may result, the condition being more intractable as age advances, and most complained of by neurasthenic patients. To overcome the difficulty it is absolutely necessary that the eyes should converge with the glasses, and if a neurotic patient insists upon the impossibility of using the eyes for near work, converging exercises with the finger or with prisms may possibly be indicated. These cases may be diagnosed by the increase of heterophoria with glasses at a near point, when the centres are in the lines of fixation for that point.

The division of asthenopia into *retinal*, from general disease, *accommodative*, from errors of refraction, and *muscular* is not sufficiently comprehensive. It does not include the effect of certain materials upon the eyes, as, for example, glazed paper; operatives who make white boxes with this material suffer from eye strain which ceases with a change of occupation. Other causes of asthenopia, such as a bent

position of the head, use of the eyes immediately after meals, poor position and character of the illumination used, are also not included in the above classification. We all know that somewhat modified daylight from above and to the left and rear is desirable, but the character of the artificial illumination which is least injurious to the eyes is still in doubt. A belief in the bad effects of insufficient illumination is well-nigh universal; that poor light causes ocular discomfort is perfectly evident, yet it is difficult to see how it could do the harm, functionally or organically, that must come from excess of illumination. In the medium limits of illumination, where increased light causes increase of vision, the latter increases only about as the logarithm of the former, and the excess of light is injurious to the retina. If we look at the history of any nation, or the comparative history of all, we see without exception that asthenopia increases directly with the increase in amount and intensity of artificial illumination. Here we have the combination of causes which produce "neurasthenopia" or ocular exhaustion, without regard to the nature of the defects existing in the structure or dynamics of the eyes: the artificial life which goes with artificial illumination, the ability to continue using the eyes when they are fatigued and should be rested, and the direct chemical effect of improper light upon the exhausted retina.